61

Frontispiece.

(a) Placing crushed stone on roadway east of Bloomington, Monroe County.

(b) Same road after completed and rolled with steam roller. See page 950.

INDIANA.

DEPARTMENT

OF

Geology and Natural Resources.

THIRTIETH ANNUAL REPORT.

W. S. BLATCHLEY,

STATE GEOLOGIST.

1905

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING
1906

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
February 12, 1906

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, March 5, 1906.

The within report has been examined and found to contain no statement of the expenditure of State funds.

WARREN BIGLER,
Auditor of State.

MARCH 6, 1906.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

FRED L. GEMMER,
Secretary to the Governor.

Filed in the office of the Secretary of State of the State of Indiana, March 6, 1906.

DANIEL E. STORMS,
Secretary of State.

Received the within report and delivered to the printer March 6, 1906.
HARRY SLOUGH,
Clerk Printing Bureau.

State of Indiana,
Department of Geology and Natural Resources.

INDIANAPOLIS, IND., February 12, 1906.

HON. J. FRANK HANLY, *Governor of Indiana:*

DEAR SIR—I have the honor to transmit to you herewith the manuscript of my eleventh annual report, the same being the Thirtieth Report of the Department of Geology and Natural Resources of the State. In the main it comprises the results of a careful investigation of the materials in each county suitable for the improvement of roads, the principal energies of the Department for the last year having been devoted to such investigation. It also embodies the results of the work accomplished by the different divisions of the Department during the calendar year 1905.

Yours very truly,

W. S. BLATCHLEY,
State Geologist.

ASSISTANTS.

L. C. WARD	Field Assistant.
J. T SCOVELL	Field Assistant.
A. E. TAYLOR	Field Assistant.
E. J. CABLE	Field Assistant.
R. W. ELLIS	Field Assistant.
J. A. PRICE	Field Assistant.
CHAS. W. SHANNON	Field Assistant.
R. E. LYONS	Chemist.
J. W. BEEDE	Paleontologist.
E. R. CUMINGS	Paleontologist.
JAMES EPPERSON	Inspector of Mines.
ANDREW DODDS	Assistant Inspector of Mines.
JONATHAN THOMAS	Assistant Inspector of Mines.
B. A. KINNEY	Supervisor of Natural Gas.
ALBERT STEVENS	Assistant Supervisor of Natural Gas.
ISADORE KESSLER	Clerk and Stenographer.
MILLARD GILLIAM	Messenger and Janitor.

DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

INDIANAPOLIS, IND.

W. S. BLATCHLEY, State Geologist.

PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.

In return, Scientific Books, Fossils, etc., and Implements of the "Stone Age" are acceptable.

State Museum, Room 126, Third Floor, State House.
Open to the public from 8 A. M. to 5 P. M., except on Sundays and legal holidays. Admission free.

Office of State Geologist, Room 89, Third Floor, State House.

port covers that region. During the season of 1905 Messrs. J. T. Scovell, A. E. Taylor, R. W. Ellis, E. J. Cable, C. W. Shannon and the writer covered the southern two-thirds of the State. Every county has been visited and a description of the more important deposits of gravel or stone in each, which are suitable for road improvement, will be found under the respective county headings.

The results show that Indiana is abundantly supplied with materials suitable for improving in a permanent manner all the more important highways of the State. Moreover, this material is well distributed, as only some eight or ten counties will have to import gravel or stone from without their bounds. These are Lake, Porter, Laporte and the greater part of Starke in the northwestern corner of the State. In these counties both gravel and stone are lacking, or are so deeply buried beneath a heavy accumulation of drift as to be unavailable. In the southwestern corner, Daviess, Dubois, Spencer and the greater part of Pike, Posey, Vanderburgh and Warrick counties are south of the drift line, and west of the sub-carboniferous limestones, so that they lack both gravel and stone suitable for road use.

Since roads covered with crushed stone or macadam are, when properly constructed, much more durable, and therefore cheaper in the long run than those of gravel, samples of limestone were collected in 72 different localities of the State, and sent to Washington, D. C., to be tested in the U. S. Road Laboratory. The results of these tests show that with few exceptions the limestones of southern and central Indiana are well adapted for the surfacing of country roads and highways. Named in the order of their superiority, the Mitchell, Huron and Niagara rocks rank best. The Devonian limestones are, in some places, too soft, and the Bedford oölitic stone should not be used for road purposes for the same reason. The locality and description of each deposit with results of tests are given in full under the respective county headings.

In many places in central and northern Indiana thick deposits of unoxidized gravel of excellent quality occur below the level of ground-water, or at such a depth as to be unavailable by ordinary methods of stripping and loading. Mr. A. E. Taylor shows in his paper that such deposits can be readily secured for road purposes by means of one of the three machines known as the gravel exca-

vator, the endless chain and the gravel pump. These machines are in operation in a number of localities in the area covered by Mr. Taylor, and have generally proven successful wherever used.

Statistics gathered from each county show that 35 per cent., or more than one-third of the public roads of Indiana, have been improved with either gravel or stone. In many, perhaps the majority of cases, however, the improvement is not what it should be for the money expended. Our roads should be built not for ourselves alone, but for future generations. It costs but little more to properly grade and drain the foundation of an improved road than it does to throw the material for the grade together in any haphazard way that will pass the inspection of an inexperienced superintendent.

To the thirty-six or more millions of dollars originally spent upon the gravel and stone roads of Indiana, at least half as much more has been added for annual repairs that would not have been needed had the roads been properly built in the first place. Heavy road rollers should be used in compacting both grade and surface before the road is thrown open to traffic, and yet in but one or two counties of the State have such rollers been used. In too many instances the stone has not been broken to the proper size, and in not a few sandstone, which should never be used as a surfacing material, has been applied. Gravel which is two-thirds sand or one-half clay is often dumped in irregular heaps upon a poorly constructed grade and left for traffic to level and compact. Not one gravel road contractor in one hundred uses screens to properly separate the gravel from the sand before placing it upon the road.

It is a well-known fact that no other department of our public works is carried on in such a slipshod manner as is that of our road improvement. The people have put up with poor dirt or mud roads for nearly a century and are, for the most part, satisfied with any makeshift put off upon them which is a temporary improvement. The average road contractor is in the business, not for the public good, but for what there is in it for himself. If a poorly constructed road will pass inspection and be received, so much the greater will be his profit. If county commissioners or county surveyors can be hoodwinked or corrupted, the contractor is, in many instances, only too willing.

The proper way to do away with this method of doing business

is to create a State Highway Commission, such as is in operation in Massachusetts and New Jersey, which shall have full supervision over all road improvement in the State. Such a commission, by fixing a standard for both gravel and stone roads and requiring strict compliance therewith, can do more to bring about proper and permanent road construction than any other force. Experienced and honest men only should be chosen as inspectors and superintendents by such State Commission, and every dollar should be accounted for in a proper business manner.

Another advance which can not come too soon is the abolishment of the present antiquated method of working out the road tax under supervisors. Such tax should be paid in cash and this, for the most part, should be used in permanently improving some certain portion of road, the improvement to be done by contract and under the proper supervision.

Coal Mining Industry of the State.

The report of the State Mine Inspector, James Epperson, of Linton, follows the paper on Roads and Road Materials. Mr. Epperson and his deputies, Andrew Dodds of Oakland City and Jonathan Thomas of Carbon, have given careful attention to the duties which they are empowered to perform and have tried to enforce impartially all laws relating to the mining industry. In their report the statistics of the coal industry for the year are given, the tables being very full and complete in detail.

I would again urge upon the legislature the necessity of a law which shall require the inspection, at least once each year, of all mines operating in the State, regardless of the number of men employed. At present the law gives the inspector power to examine only those mines in which ten or more men are at work. Many mines employ from six to eight men, and the aggregate amounts to a large number. The life of any one of these men is as valuable as that of a man working in a larger mine, yet under the present law they receive no protection whatever. The air where they work is often extremely foul, man-shafts are more often lacking than present, and too little attention is given to the condition of the roof. Some of these abuses could at least be ameliorated by the occasional visit of an inspector invested with power to better the conditions where possible.

GAS AND OIL INDUSTRIES OF THE STATE.

The report of B. A. Kinney, State Natural Gas Supervisor, follows that of Mr. Epperson. Mr. Kinney has been very active in the searching out and prosecuting offenders against the gas waste laws. He states that in a number of localities which had been abandoned as nonproductive gas territory, new wells were sunk during the year which yielded a fair supply of that valuable fuel. For example, the Chicago Gas Company, having exhausted their main territory in the vicinity of Fairmount, Grant County, went back to territory which was abandoned several years ago, near Greentown and Sycamore, Howard County, and are there getting a number of fair producing gas wells.

In northwestern Grant County and southern Wabash County, a number of light producing wells were drilled in during the year, and from them the city of Marion derives much of its gas for domestic purposes. Good producers were also finished in Jay County. Natural gas for domestic purposes will doubtless be furnished the cities of the "gas belt" for a number of years, but for factory use it is almost wholly a thing of the past.

Pumping stations, which artificially exhausted the gas and thereby created a vacuum in the gas producing rock, thus allowing the water to flow in and drown out the fuel, have caused the abandonment of much territory which would have yielded longer had not such stations been in use. The poor plugging of abandoned wells has also been the cause of a failure of the supply in parts of the field. A more stringent plugging law would doubtless prolong the life of the present productive territory.

A paper on the "Petroleum Industry in Indiana in 1905" gives in detail the new developments and statistics for the year in that important industry. On account of the low average price of crude oil, 84 4/5 cents as against $1.07½ in 1904, developments were retarded and the total production fell off 362,230 barrels, or 3.2 per cent; the output for the year being 10,969,308 barrels, valued at $9,305,473.

Following the usual custom of completing the annual report with a paper on natural history or paleontology, the present volume ends with one on the latter subject by Profs. Cumings and Beede, the gentlemen in charge of the Department of Geology at Indiana University. It is entitled "Fauna of the Salem Lime-

The body and tongue are hewn from wood and there is not a nail or a scrap of iron about it. Long after the invention of such a simple carriage, a front pair of wheels was added and the cart became the ordinary springless wagon, for the first time fitted for the carriage of heavy burdens over broad roadways.

IMPROVED ROADWAYS OF THE OLD WORLD.

The massive roadways about Rome were the first to be constructed especially for wheeled vehicles. As nearly as can be ascertained they were begun about 400 years B. C. With the extension of the Roman Empire the system of road building was continued into what is now France, Switzerland and Great Britain as far north as the Scottish border. These Roman roads were first built as avenues of conquest, to enable large bodies of troops to march compactly and be closely followed by their provision wagons and the artillery of the times. Afterwards they became the routes or arteries of a great commerce, which sprang up among the various Roman States and bound them together into one of the greatest Empires known to man.

The sections of these Roman roads show them to have been exceedingly thick and massive. All of them had a foundation of heavy stone with a layer of cement at a higher level. The surface was paved with flat stones set in cement. Where such stone was not available, the surface was of a mortar mixed with bits of stone. Layers of sand or gravel were, in many places, introduced between the foundation and surface, so that the total thickness of the roadbed was often three feet or more. They were built by slave labor and, "measured in terms of the price of labor in this country, must have cost from $30,000 to $100,000 a mile. It is not too much to say that at least three-fourths of the expenditure was really wasted. It is true that the brutal massiveness of the construction has enabled these ways to survive for fifteen or more centuries after their builders passed away, but this was not the intention of the constructors. They doubtless intended to do no more than seemed to their ignorance needful."*

With the downfall of the Roman Empire the building of great highways ceased, nor was it begun again until the latter part of

*Shaler.—"American Highways," p. 7.

thin layer of broken stone to fill up the irregularities, as the French engineer had done, Telford used six inches of broken stone in two layers. The lower four inches was composed of angular fragments, none weighing more than six ounces. After being either rolled thoroughly or compacted by the wheels of travel, an additional two inches of the same stone, slightly smaller in size, was added and the rolling continued till the surface was crushed and compacted to smoothness.

Macadam made a notable advancement in cheapening stone road construction by abandoning the paved foundation beneath the crust of broken stone. He insisted that no large stone should ever be employed in road making, and most modern road builders practice his principle "that small angular fragments are the cardinal requirements."

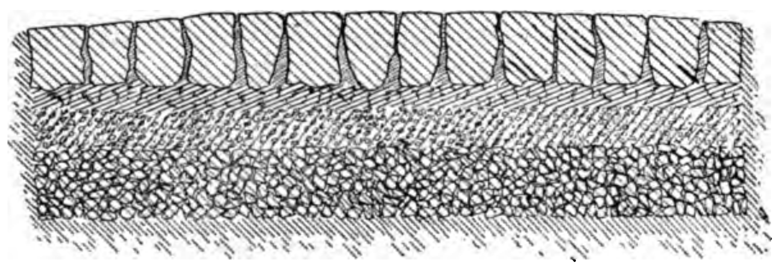

Fig. 1. Roman Road.

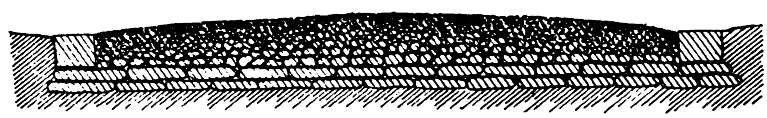

Fig. 2. Early Eighteenth Century Road.

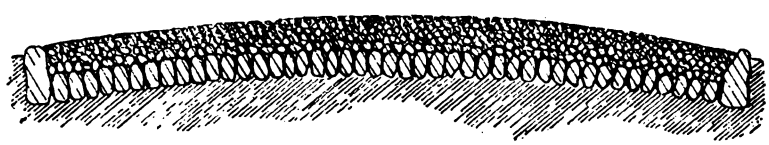

Fig. 3. Late Eighteenth Century Road.

Fig. 4. Modern Macadam Road.

FIGS. 1–4 SHOW THE RELATIVE THICKNESS OF OLD AND MODERN ROADS.*

*These illustrations are from Vol. III of the Maryland Geological Survey, page 287.

Macadam was thus the first engineer to show that a road built of small fragments of broken stone, when properly compacted, would maintain its shape without a paved foundation, provided the earth beneath was not of soft clay or muck, which would readily become mud when wet. He saw that such a road, properly built, would prevent the passage of water into the under earth, and therefore rest on a dry and firm foundation. He earnestly advocated the principle that the success of all artificial road building depends wholly upon the making and maintaining of a solid and dry foundation. If it be otherwise the crust or waterproof coating or roof of broken stone is useless.

Both the Telford and Macadam systems of road construction have been used in Indiana, the former, however, only in limited areas in the southern counties. The relative value of the two systems can most always be determined by the local circumstances, conditions, and necessities under which the road is to be built. The Telford system seems to have the advantage in swampy, wet places or where the soil is in strata varying in hardness, or where the foundation is liable to get soft in spots. Under most other circumstances experienced road builders prefer the Macadam construction, not only because it is considered best, but also because it is much cheaper.

First Improved Highways of Indiana.

Having sketched briefly the advance of the road building spirit in the Old World, we now turn to the new, where, says Shaler, "for a hundred years after the settlement of the Atlantic seaboard began there was hardly any way in this country fit for carriages. The intercourse between the settlements was maintained by boats or by paths which were barely fit for horsemen and pack-animals. With the gradual increase in wealth and population the use of carriages increased. The original trackways were cleared so as to permit the passage of vehicles, and something like roads began to be established. It was, however, another century before any considerable part of the traffic of the country passed over ordinary highways. So far as the inquiries of the writer have extended, there appears no reason to believe that any well paved roads existed in this country outside of the cities and towns until after the year 1800."*

*American Highways, p. 18.

The history of the early Indiana roads is very similar to that of those of the Atlantic seaboard. The streams of the State and the trails of the Indians furnished, for many years, avenues of travel and commerce between the settlements. As the towns grew in size and wagons and carriages were introduced, the old pack trails were cleared and broadened, and bridged where necessary. Many of these early roads were for years so little traveled that they were little more than blazed trails through the wilderness. Along them the traveler was oftentimes directed by notches cut in the sides of the larger trees. Even at this day some of the main public roads of certain counties of the State are known as the Two-Notch or Three-Notch roads.

Along the swampy places of these primitive roads and, in some localities along the entire roadway, a corduroy or "laid road" was often built of small logs or saplings placed side by side across the way, thus forming a rude, bridge-like structure. On the best of these the cross timbers were held in place by heavy lengthwise ones on the sides. Such roads, while affording protection against miring, especially in early spring when the roads were at their worst, were very rough and exceedingly tiresome to travel. Remnants of these corduroy roads are yet to be found in the lowlands of many counties of the State.

Up to 1832, as far as can be ascertained, no one of the principal highways of Indiana had been improved with either stone or gravel. Robert Baird, writing in that year, stated that "the roads in this State (Indiana) are good in summer but bad in winter, on account of their being entirely of clay, excepting the corduroy roads, as they are called. A State Road is now making from Indianapolis to Michigan Territory, called the Michigan Road. The National road will pass through Indianapolis from Columbus to St. Louis. When it shall have been completed it will be of great advantage to the State."*

Baird included in his work small maps of each of the States of the Mississippi valley which showed the more prominent roads then in use. That of Indiana has been reproduced in the accompanying etching. The figures along the roads indicate the distances from place to place.

*"View of the Valley of the Mississippi, or Emigrants' and Travelers' Guide to the West," 1832, p. 156.

Between 1830 and 1835 there was a great awakening of the public road spirit in the United States. The era of "internal improvements" was on, and canals, railways and improved roads were projected, either on paper or in reality in many of the States. The people of Indiana caught the fever, and in 1835 the Legislature authorized the surveys of six important routes, as follows:

1. A route for a railroad or turnpike road from Madison via Indianapolis, Danville and Crawfordsville, to Lafayette.

2. A route for a railroad or turnpike road from Crawfordsville via Greencastle, Bloomington, Bedford and Salem, to New Albany.

3. A route for a railroad from Evansville via Princeton to Vincennes.

4. A route for a railroad from Vincennes to Terre Haute.

5. A route for a macadamized turnpike road from New Albany via Greenville, Fredericksburgh, Paoli, Mount Pleasant and Washington to Vincennes.

6. The completion of the surveys and estimates on the Lawrenceburgh and Indianapolis railway.

Noah Noble was then Governor of Indiana, and, at his request, made to the United States Topographical Bureau for an engineer of ability to take charge of the surveys, Howard Stansbury, U. S. Assistant Civil Engineer, was detailed for the service. The reports of Mr. Stansbury and his several assistants were published in the House Documentary Journal for 1835-1836, and are very full and exceedingly interesting. The letter of instructions furnished Stansbury by Governor Noble on April 24, 1835, contained the following paragraphs:

"At the late session of the Legislature of the State, the adoption of a connected and general plan of improvement affording commercial facilities to every section, was the measure occupying most of the deliberations of the body, but the absence of such facts and information as seemed indispensable, prevented the adoption of any. To enable the Legislature at its next session to act advisedly in the premises the surveys and estimates provided for by law, of which you have a copy, were ordered.

"The law, as you will discover, would seem to leave it for the Governor to determine whether the surveys upon the Madison and

ever, of other data in addition to those furnished by the survey of this railroad, we are enabled to arrive at the comparative expense of constructing a turnpike road from Madison to Lafayette as follows:

"The whole cost from Madison to Indianapolis amounts to $303,957, or an average of $3,554 per mile.

"From Indianapolis to Lafayette via Danville and Crawfordsville, the whole cost will be $290,989. The average cost, $3,919 per mile."

"From Indianapolis to Lafayette, by the direct route, the whole cost will be $178,390. The average cost $2,948 per mile. Giving as the cost of a turnpike road from Madison to Lafayette by Danville and Crawfordsville, 159.76 miles, the gross sum of $594,946 —averaging per mile $3,724; and by the direct route, 146 miles, the gross sum of $482,347—averaging per mile $3,303.

"As a distinction between a turnpike and a macadamized turnpike road seems to be recognized and drawn by the law, the estimates do not embrace the cost of covering the road with stone, but contemplate only an earth road well graded and drained."

It is interesting to note that single track railways were afterwards built by two different corporations, which together covered the direct route as mentioned above. These were, viz., The Indianapolis and Madison railway, completed October 1, 1847, and the old Indianapolis and Lafayette railway, now a part of the Chicago Division of the Big Four, completed in December, 1852.

A turnpike between Lafayette and Crawfordsville was begun by the State, but after expending $56,144, work on it was suspended in 1839. This was to run to Indianapolis by way of Danville, in accordance with the survey above made.

Route 2.

A route for a railroad or a turnpike road from Crawfordsville via Greencastle, Bloomington, Bedford and Salem, to New Albany.

In his letter of instructions to Edward Watts, the Assistant Engineer in charge of the survey for Route 2, Mr. Stansbury used the following paragraph:

"Should the inequalities of the country prove such as would, in your opinion, render the construction of a railroad impractic-

The body and tongue are hewn from wood and there is not a nail or a scrap of iron about it. Long after the invention of such a simple carriage, a front pair of wheels was added and the cart became the ordinary springless wagon, for the first time fitted for the carriage of heavy burdens over **broad roadways.**

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*Shaler.—"American Highways," p. 7.

the Eighteenth Century. A military motive was again the leaven which called it into existence, for Napoleon I. was compelled to improve the roads of France and Switzerland in order to move rapidly his vast armies from one part of his Empire to another. The good roads which he left France are to be reckoned among the best and most lasting of his works.

These roads built by Napoleon were, for the most part, patterned after a plan proposed about 1764 by a French engineer named Tresaguet. In his method the stone element of the road consisted of a foundation made much in the manner of the Roman ways, composed of large fragments of rock set closely together, their projecting points being broken off and their interspaces filled with smaller bits. On this heavy foundation there was laid a covering of small fragments such as are used on our modern broken-stone roads.

From France the road-building spirit spread to Great Britain. Here the needs of commerce and not warfare was the impelling motive to better highways; so that by the middle of the Nineteenth Century Britain was better provided with good roads than any other country on the earth. The most of the British roads were built of broken stone, and after the plans of one or the other of two Scottish engineers to whom, more than to any others, is due the credit for the modern methods of constructing stone roads. These men were Thomas Telford and John L. Macadam.

METHODS OF TELFORD AND MACADAM.

Telford, from 1803 to 1830, superintended the construction of nearly 1,000 miles of road in the Highlands of Scotland, besides many lines through northern Wales, surmounting in both localities great natural difficulties. He followed to a certain extent the methods of the old Romans and of the Frenchman, Tresaguet, in that the foundation or base of his roads were constructed of pieces of stone four to seven inches in dimensions, laid by hand upon the roadway. He differed from the Roman and French plans in that between such stones smaller pieces were packed to complete a compact layer seven inches deep in the middle of the road and graduated to four inches on the sides, thereby giving an arched form to the road when completed. Moreover, instead of only adding a

thin layer of broken stone to fill up the irregularities, as the French engineer had done, Telford used six inches of broken stone in two layers. The lower four inches was composed of angular fragments, none weighing more than six ounces. After being either rolled thoroughly or compacted by the wheels of travel, an additional two inches of the same stone, slightly smaller in size, was added and the rolling continued till the surface was crushed and compacted to smoothness.

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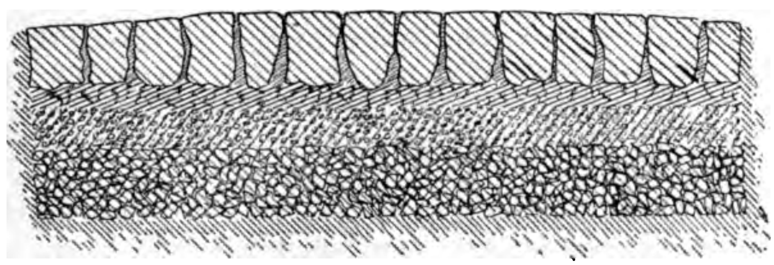


Fig. 1. Roman Road.

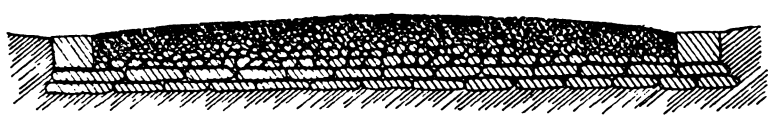
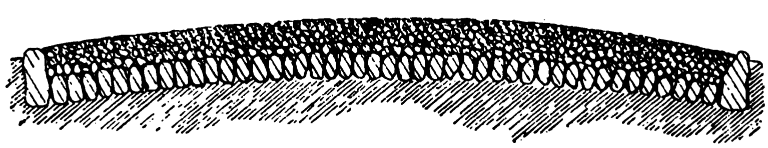


Fig. 2. Early Eighteenth Century Road.



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*American Highways, p. 18.

The history of the early Indiana roads is very similar to that of those of the Atlantic seaboard. The streams of the State and the trails of the Indians furnished, for many years, avenues of travel and commerce between the settlements. As the towns grew in size and wagons and carriages were introduced, the old pack trails were cleared and broadened, and bridged where necessary. Many of these early roads were for years so little traveled that they were little more than blazed trails through the wilderness. Along them the traveler was oftentimes directed by notches cut in the sides of the larger trees. Even at this day some of the main public roads of certain counties of the State are known as the Two-Notch or Three-Notch roads.

Along the swampy places of these primitive roads and, in some localities along the entire roadway, a corduroy or "laid road" was often built of small logs or saplings placed side by side across the way, thus forming a rude, bridge-like structure. On the best of these the cross timbers were held in place by heavy lengthwise ones on the sides. Such roads, while affording protection against miring, especially in early spring when the roads were at their worst, were very rough and exceedingly tiresome to travel. Remnants of these corduroy roads are yet to be found in the lowlands of many counties of the State.

Up to 1832, as far as can be ascertained, no one of the principal highways of Indiana had been improved with either stone or gravel. Robert Baird, writing in that year, stated that "the roads in this State (Indiana) are good in summer but bad in winter, on account of their being entirely of clay, excepting the corduroy roads, as they are called. A State Road is now making from Indianapolis to Michigan Territory, called the Michigan Road. The National road will pass through Indianapolis from Columbus to St. Louis. When it shall have been completed it will be of great advantage to the State."*

Baird included in his work small maps of each of the States of the Mississippi valley which showed the more prominent roads then in use. That of Indiana has been reproduced in the accompanying etching. The figures along the roads indicate the distances from place to place.

*"View of the Valley of the Mississippi, or Emigrants' and Travelers' Guide to the West," 1832, p. 156.

Fig. 5. Showing the principal roads of Indiana in 1832.

Between 1830 and 1835 there was a great awakening of the public road spirit in the United States. The era of "internal improvements" was on, and canals, railways and improved roads were projected, either on paper or in reality in many of the States. The people of Indiana caught the fever, and in 1835 the Legislature authorized the surveys of six important routes, as follows:

1. A route for a railroad or turnpike road from Madison via Indianapolis, Danville and Crawfordsville, to Lafayette.

2. A route for a railroad or turnpike road from Crawfordsville via Greencastle, Bloomington, Bedford and Salem, to New Albany.

3. A route for a railroad from Evansville via Princeton to Vincennes.

4. A route for a railroad from Vincennes to Terre Haute.

5. A route for a macadamized turnpike road from New Albany via Greenville, Fredericksburgh, Paoli, Mount Pleasant and Washington to Vincennes.

6. The completion of the surveys and estimates on the Lawrenceburgh and Indianapolis railway.

Noah Noble was then Governor of Indiana, and, at his request, made to the United States Topographical Bureau for an engineer of ability to take charge of the surveys, Howard Stansbury, U. S. Assistant Civil Engineer, was detailed for the service. The reports of Mr. Stansbury and his several assistants were published in the House Documentary Journal for 1835-1836, and are very full and exceedingly interesting. The letter of instructions furnished Stansbury by Governor Noble on April 24, 1835, contained the following paragraphs:

"At the late session of the Legislature of the State, the adoption of a connected and general plan of improvement affording commercial facilities to every section, was the measure occupying most of the deliberations of the body, but the absence of such facts and information as seemed indispensable, prevented the adoption of any. To enable the Legislature at its next session to act advisedly in the premises the surveys and estimates provided for by law, of which you have a copy, were ordered.

"The law, as you will discover, would seem to leave it for the Governor to determine whether the surveys upon the Madison and

Lafayette and New Albany and Crawfordsville lines should be for a *Railway* or a turnpike; it is believed, however, that it was the wish and intention of the Legislature to include both. There are no means by which to ascertain whether the Legislature designed the surveys and estimates should be for double or single tracks, the law being silent on the subject, but as a single track would not be of great value to the public, it is thought advisable to make them with a view to the construction of a double track, but if found that it will not require much additional time and expense, estimates for each will be preferred.

"In the construction of her public works, it has been the policy of the State to embark in none of a temporary character, therefore the estimates should embrace materials and structures of a durable and permanent kind only."

Since routes 1 and 2 include surveys and estimates for turnpikes as well as for railways, and route 5 was wholly for a macadamized turnpike, it is thought that the following extracts, taken verbatim from the reports of the engineers, will be of interest in this connection, as showing the kind of roads it was proposed to build 70 years ago, as well as the estimated cost of the same:

Route 1.

A route for a railroad or a turnpike road from Madison via Indianapolis, Danville and Crawfordsville, to Lafayette.

"The whole estimated cost of the railroad with single track from Madison to Indianapolis (including the inclined plane) amounts to $1,094,484, giving an average of $12,800 per mile.

"The whole cost from Madison to Lafayette via Danville and Crawfordsville, amounts to $2,351,697, giving an average of $14,721 per mile.

"The whole cost from Madison to Lafayette by a direct route, 146 miles, amounts to $1,666,797, giving an average of $11,416 per mile.

"An examination for a railroad does not necessarily furnish all the data that would be required to enable a minute estimate to be made of the cost of a turnpike road; for in many instances the trace of the one would properly occupy ground which, for the other, would be inexpedient or impracticable. By the aid, how-

ever, of other data in addition to those furnished by the survey of this railroad, we are enabled to arrive at the comparative expense of constructing a turnpike road from Madison to Lafayette as follows:

"The whole cost from Madison to Indianapolis amounts to $303,957, or an average of $3,554 per mile.

"From Indianapolis to Lafayette via Danville and Crawfordsville, the whole cost will be $290,989. The average cost, $3,919 per mile."

"From Indianapolis to Lafayette, by the direct route, the whole cost will be $178,390. The average cost $2,948 per mile. Giving as the cost of a turnpike road from Madison to Lafayette by Danville and Crawfordsville, 159.76 miles, the gross sum of $594,946 —averaging per mile $3,724; and by the direct route, 146 miles, the gross sum of $482,347—averaging per mile $3,303.

"As a distinction between a turnpike and a macadamized turnpike road seems to be recognized and drawn by the law, the estimates do not embrace the cost of covering the road with stone, but contemplate only an earth road well graded and drained."

It is interesting to note that single track railways were afterwards built by two different corporations, which together covered the direct route as mentioned above. These were, viz., The Indianapolis and Madison railway, completed October 1, 1847, and the old Indianapolis and Lafayette railway, now a part of the Chicago Division of the Big Four, completed in December, 1852.

A turnpike between Lafayette and Crawfordsville was begun by the State, but after expending $56,144, work on it was suspended in 1839. This was to run to Indianapolis by way of Danville, in accordance with the survey above made.

Route 2.

A route for a railroad or a turnpike road from Crawfordsville via Greencastle, Bloomington, Bedford and Salem, to New Albany.

In his letter of instructions to Edward Watts, the Assistant Engineer in charge of the survey for Route 2, Mr. Stansbury used the following paragraph:

"Should the inequalities of the country prove such as would, in your opinion, render the construction of a railroad impractic-

able or very expensive, your operations will be directed to the attainment of a route for a hard, compact traveling way, thirty feet wide, with the upper surface sufficiently elevated to prevent its being affected by any neighboring stagnant water; having in no case a longitudinal slope of more than three and a half degrees, and no horizontal curvature too abrupt to admit of carriages of every description passing over it with perfect facility."

From the report of Mr. Watts, the engineer in charge of the route, I quote as follows:

"By reference to the maps you will discover that a railroad, in order to pass through the points prescribed by law, necessarily passes over undulating country, crossing water courses nearly at right angles, thereby occasioning ascents and descents entirely inadmissible upon a railway, which could only be removed by long, deep cuts and heavy embankments, the cost of which would be so enormous as to render any idea of the construction of the work out of the question.

"The estimate has therefore been made only for a turnpike road thirty feet wide on top, having in no case a longitudinal slope of more than three and a half degrees. The ground is to be well grubbed and cleared forty feet on each side of the center, making an opening of 80 feet; and have ditches cut of such form and dimensions as will ensure the drainage of the road. This estimate of the cost of each of the six divisions into which it was divided is as follows:

First division, from New Albany to Greenville, 12 miles	$36,090
Second division, from Greenville to Salem, 19 miles	52,671
Third division, from Salem to Bedford, 32 miles	133,220
Fourth division, from Bedford to Bloomington, 27 miles	83,753
Fifth division, from Bloomington to Greencastle, 40 miles	177,944
Sixth division, from Greencastle to Crawfordsville, 28 miles	87,756
Total—158 miles	$571,438
Add ten per cent. for contingencies	57,143
Total cost of road	$628,581

Giving an average of $3,978 per mile.

"In closing this communication, it may be proper to advert to the effect the contemplated improvement would be calculated to exert upon the future prospects of this part of the State. Possess-

ing a soil rich and productive, and a population industrious and enterprising, its energies are now subdued and its advancement retarded for the want of a good and never failing avenue to market. Deprived of the advantages of a communication by water with the Ohio River, the cost of transportation over roads which are rendered impassable for loaded teams by every heavy shower, is too great to afford a fair competition with articles of produce which find their way to market by other and cheaper channels. As the cost of transportation decreases, this disparity would be lessened, and its effects upon the resources of the country would be sensibly felt."

The Legislature of 1836 ordered the building of the turnpike and the macadamizing of the same. The estimate of macadamizing the full length of the road was first given at $960,000, but in 1839 had been reduced by the State engineer to $645,000. No macadamizing was ever done. The grading and bridging was begun between New Albany and Salem and between Greencastle and Crawfordsville. When the public work was suspended in 1839, the grading and bridging on 15 miles between New Albany and Salem had been completed at a cost of $61,844. The remaining 18 miles between those two points were estimated to cost $116,532. About 21 miles of this division of the road was, in 1848, turned over to the New Albany and Salem railway and used as a portion of the grade.

Up to 1839 the State had expended $55,944 on the division north of Greencastle. This, in time, was turned over to a private corporation, and, after improving with gravel, became a toll road. It is now one of the free improved county roads of Putnam and Montgomery counties. One of the old wooden bridges, built in 1838, across Raccoon Creek just south of the station of Raccoon, on the C., H. & D. Railway in Putnam County, is still in use and in a fair state of preservation. It was crossed by the writer in December, 1905.

The railway between New Albany and Lafayette, though rejected as impracticable in the paragraph cited above from Mr. Watts, was begun in 1847 and completed in 1854. It is now a part of the main line of the C., I. & L. (Monon) extending from Chicago to Louisville, Ky.

Route 5.

A route for a macadamized turnpike road from New Albany via Greenville, Fredericksburgh, Paoli, Mount Pleasant and Washington to Vincennes.

The assistant engineer, Edward Watts, in charge of the survey of this route, in his report stated that "the accompanying estimate has been made for a road thirty feet wide on top, having in no case a longitudinal slope of more than three and a half degrees, and covered with stone broken into pieces weighing not more than four ounces. The bed of the road is to be formed nearly flat, having a slope of one inch in three feet from the center to the sides. Twenty feet of the center to be covered to a depth of three inches with clean stone broken as above. Second year an additional covering of three inches will be put on. Third year three inches more will be necessary, leaving the macadamized stone covering nine inches deep at the center, and six at the edges. No stone to be used but such as are hard, as granite, flint or limestone."

His estimate of the cost of each of the six divisions into which the road was subdivided was as follows:

	No. of Miles.	Cost of Grading.	Cost of Covering with Stone
First division, Vincennes to Washington..	20.41	$121,901	$449,977
Second division, Washington to Mt. Pleasant	15.52	25,634	146,181
Third division, Mt. Pleasant to Paoli.....	27.09	168,086	292,396
Fourth division, Paoli to Fredericksburgh.	17.77	56,483	94,454
Fifth division, Fredericksburgh to Greenville	11.64	42,500	75,134
Sixth division, Greenville to New Albany.	12.37	36,090	81,906
Totals	104.80	$450,697	$1,140,050

It is thus shown that the cost of a macadam road covered with broken stone to a thickness of nine inches was, in 1835, estimated at $15,178 per mile, or at least seven times as much as it would cost today. It must be remembered, however, that much of the roadway had to be cleared and grubbed through a primeval forest, so that the grade was necessarily much more costly. The stone used for macadamizing was required to be broken by hand by the side of the road and not at the quarry.

In commenting upon the report of Mr. Watts, the chief engineer, Mr. Stansbury, said: "It will at once be observed that the expense of covering the road with stone bears an uncommonly large proportion to the cost of graduation. Of this amount $450,-000, or nearly one-half, will be required between Vincennes and Washington, a distance of but 20.41 miles. On this portion of the road no stone suitable for macadamizing can be obtained. The nearest point at which it occurs in sufficient quantity is at such a distance that the cost of its transportation is the principal item of expense. The cost of the stone alone on this division is equal to the whole cost of graduation, including bridging and masonry throughout the line.

"By reference to the report of Mr. Watts it will be perceived that upon other portions of the road, stone can be procured within a comparatively reasonable distance. In consideration of this variation in expense it is recommended that stone should be used upon those portions only where it can be conveniently furnished, and that the remainder of the road should be well graded and drained in strict conformity with the principles laid down in my instructions to the gentlemen in charge of the surveys, which are those approved in the service of the United States. As has been the case upon the National road, the graduation may lead to the discovery of stone in the vicinity of the line, the existence of which is at present unknown, and obviate the necessity of its transportation from a distance."

The Legislature of 1836, in obedience to the almost universal demand of the people of the State, passed an internal improvement bill appropriating nearly $16,000,000 for the completion of canals, railways and macadam roads. Of this amount $1,150,000 was for the building of the New Albany and Vincennes road as surveyed. The contract for building the road as far as Paoli must have soon afterward been let, as the State Board of Internal Improvement, in its report made December 16, 1837, has the following sentence: "On the New Albany and Vincennes macadamized road the gradings, culverts and bridges are nearly completed from New Albany to Paoli, a distance of 41 miles; and early in the next season the application of metal will be commenced."*

*Second Ann. Rep. State Board of Internal Improvement. p. 7, in Documentary House Journal of the State of Indiana, 1837.

In the report of John A. Graham, member of the above mentioned Board, made in October, 1839, it is stated that the cost for grading and bridging the road from New Albany to Paoli averaged $7,445 per mile, while the cost of macadamizing with broken stone averaged $5,091 per mile, making the total cost $517,034, or $12,537 per mile, between the points mentioned.* The stone covering which the contracts required to be put on was 18 feet wide, besides the slopes of the metaling at the edges, 11 inches deep in the center and 7 at the sides, its upper surface having a curvature of 4 inches. The stone was put on in two layers, the bottom layer being broken to the size of eight ounces, and the upper to five ounces. Hard limestone only was allowed to be used.

The grading and bridging, excluding White River bridge, of the twenty-five and a half† miles between Paoli and Mount Pleasant, Martin County, was let for $136,268. This division was never macadamized, as in November, 1839, the State was unable to sell more bonds, and, with certain minor exceptions, all public works were suspended. The road was finished to Paoli in 1839, and was opened as a toll road between New Albany and Paoli by the State on October 10, 1840.‡ On November 30, 1839, Mr. Graham reported of it: "The manner in which this road has been built is highly creditable to the contractors. The materials which have been furnished are of the first quality; the work done is of the most durable kind; and I have no hesitation in saying that it will bear a comparison with any other work of the kind."

The toll received during the first month was $657.98. The New Albany and Vincennes mail stage also entered into an agreement to pay $605.90 per year for the use of the road. On that

*Doc. Journ. of Ind., 1839, p. 72.

†This division had been shortened and the maximum grade reduced to 2½ degrees by a new survey.

‡Rev. W. J. Frazer, of Elkhart, Indiana, whose father was, during most of the period, the engineer in charge of the road, in a recent letter to Mr. A. B. Ham, of Paoli, gave an interesting account of the completion of the New Albany and Paoli pike to the latter town. After speaking of the National road and its importance to central Indiana, he adds: "But a new necessity was upon the State, to satisfy the demands of transit across the southern end of its domain. Emigrants, prospectors and travelers were coming down the Ohio River to the falls. There they would naturally desire to leave the waterway, and take a shorter course to St. Louis. So the New Albany and Vincennes Turnpike was projected, to connect the Falls cities of Louisville, Jeffersonville and New Albany with the historic metropolis and capital, Vincennes. A young engineer, John Frazer, who had come from the East to Richmond to superintend the construction of a portion of the National Road, was called to take charge of this one. Abundance of "metal" was at hand in the limestone hills through which it was to wind its serpentine way.

basis the income of the road was about $8,500 per year. It was operated by the State until May, 1851, and then turned over to a private corporation, which kept it in repair and collected toll until March, 1899, when that portion of it within Orange County was bought and made a free road. Orange County paid $11,000 for the eleven miles within her bounds, the remaining 30 miles in Washington, Harrison and Floyd counties are still operated as a toll road. Being the first macadamized road in the State, and the only one ever completed with State funds, the New Albany and Paoli road has been deemed worthy of especial mention.

The Old National Road in Indiana.

The old National Road, "that monument of a past age, which carried thousands of population and millions of wealth into the West, and more than any other national structure in the land served to harmonize and strengthen, if not to save the Union," was built to answer a nation's needs. It was first proposed in 1802 and was begun in 1806. Previous to this date, in the Act admitting Ohio, two per cent. of the proceeds of her public lands were reserved to be applied to the construction of public highways through the State. When Indiana was admitted, three per cent. of the income from her public lands was reserved for the same purpose.

Starting at Cumberland, Maryland, the National Road was first projected to Wheeling, on the Ohio River, but in May, 1820, Congress appropriated $10,000 for laying out the road between Wheeling and a point on the left bank of the Mississippi River,

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It was begun in State Street, New Albany; it climbed the mountainous "knobs" in many a flowing curve and gradation, never exceeding three degrees; it stretched away over occasional level reaches, firm, white and solid as the Appian Way. It had the customary wooden bridges for the larger streams, but handsome stone culverts for the smaller. When the builders got within a few miles of Paoli, a great concourse of the citizens went out to meet them, and held a joyous picnic, and made speeches of congratulation. The young engineer was the hero of the hour. The macadamizing was completed as far as Paoli, the county seat of Orange County—a white thread winding among the green hills and beside the clear streams; the grading was carried through to Vincennes, twisting in many a horseshoe bend and spiral; a telegraph line strung its slender filament beside the road; the gay tallyhoes came rumbling through; the driver's horn awoke the echoes; when suddenly the work stopped; a portentous sound had been heard in the woods. It was the voice of the locomotive."*

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*As shown in the text, it was not the toot of the locomotive, but the lack of the almighty dollar, that stopped the work on the road. The first railway in Indiana was not completed until about ten years later.—W. S. B.

between St. Louis and the mouth of the Illinois River; the road to be 80 feet wide and on a straight line. In March, 1825, an appropriation of $150,000 was made for building the road between Wheeling and Zanesville, Ohio, and for completing the surveys for its extension to the permanent seat of government in Missouri, the same to pass by the seats of government of Ohio, Indiana and Illinois. The work was pushed westward through Ohio to the Indiana line, reaching that point about 1827. Meanwhile, by means of an appropriation of $51,600 made in March, 1829, and of another for $60,000 in May, 1830, the work of opening the road east and west from Indianapolis was begun. Other appropriations for the work in Indiana were as follows:

March 2, 1831, $75,000, for opening, grading, etc., including bridge over White River near Indianapolis, and progressing to the eastern and western boundaries.

July 3, 1832, $100,000 for continuing the road in Indiana, including bridges over the east and west branches of Whitewater River.

March 2, 1833, $100,000 to continue the work in Indiana.

June 24, 1834, $150,000 for continuing the road in Indiana.

March 3, 1835, $100,000, for continuing the road in Indiana.

July 2, 1836, $250,000 for continuing the road in Indiana, including the materials for a bridge over the Wabash River, the money to be expended in completing the greatest possible continuous portion of said road, so that said finished part may be surrendered to the State.

March 3, 1837, $100,000 for continuing the road in Indiana.

May 25, 1838, $150,000 for continuing the road in Indiana, including bridges.

About this date the panic of 1837-1840 was being felt and no more appropriations were granted. In 1848 the road was turned over to the respective states through which it passed. Of the total amount, $6,824,919, appropriated by Congress for making, repairing and continuing the road, but $1,136,600 were allotted to Indiana, and this sum was paid from the fund reserved when the State was admitted into the Union. Of this amount nearly one-half, or $513,099, was expended for bridges and masonry.

When Indiana and Illinois received the road from the National Government it was not completed, though graded and bridged as

far west as Vandalia, then the capital of Illinois. In Indiana it was nowhere macadamized or graveled, except on a few miles about Richmond and Indianapolis. In 1850 the Wayne County Turnpike Company was organized, and absorbed, under a charter granted by the State, that portion of the road, 22 miles in length, within that county. This company then graveled the road and operated it as a toll road until 1890-1894, when it was purchased by the several townships through which it passed and made free from tolls.

From Wayne County westward the road in Indiana passed through Henry, Hancock, Marion, Hendricks, Putnam, Clay and Vigo counties. That portion in Henry County was secured by a private corporation, graveled and made a toll road about 1853. In 1849 the Central Plank Road Company, composed of prominent citizens of Marion and Hendricks counties, was granted that portion of the road extending from the east line of Hancock County to the west line of Putnam, for the purpose of constructing a plank road. With the granting of the road to these several corporations the old National Road as a public institution, fostered by the nation or the State, ceased to be. It had fulfilled its high purpose, and was superseded by better things which owed to it their coming. It was built by the people and for the people. It made possible that interchange of commerce and that exchange of the courtesies of social life which were so necessary among the states of a great and growing republic. It was in truth—

"A Nation's thoroughfare of hopes and fears,
First blazed by the heroic pioneers
Who gave up old home idols and set face
Toward the unbroken West to found a race
And tame a wilderness, now mightier than
All peoples and all tracts American."

Toll Roads in Indiana.

From 1850 to 1890 the majority of improved gravel or stone roads in Indiana were constructed by private corporations and maintained, often with great profit, by the charge of toll. A company would be organized and a charter for a certain highway obtained from the State or the county. Stock would be subscribed and sold for the purpose of securing funds to construct

the road. Dividends on the stock were paid from the toll receipts, usually quarterly, and ran from 7 to 15, or even 20 per cent. per annum. Such a method of constructing improved roads is beneficial only in the early history of a community, before the settlers are able to spare the time or means to build such roads. As the country becomes more settled and towns and factories increase in number, the toll system becomes a heavy tax upon the farming class. The roads are mostly held by the capitalists of the towns, and are administered solely with reference to dividends. In this way the free intercourse of the people is obstructed; and the country folk of the poorer sort often can not afford to make any journeys save those which are certain to bring them a good money return.

The people of Indiana, especially those of the northern and central thirds of the State, where many toll roads were in operation, finally learned that the toll road system was harmful to the best interests of thickly settled communities, and in 1889 a law was passed providing that upon petition of 50 freeholders in any township the question of the purchase of the toll roads of that township could be taken up. A board of viewers was then to be appointed by the county commissioners, to determine the value of such toll roads as were proposed to be purchased, after which an election was to be held. If the majority of the voters of the township favored the purchase of the roads at the price appraised by the viewers, this price was offered the owners of the road. If accepted, county bonds were to be issued, providing for the payment, and a special tax levied in the township for the redemption of the bonds and payment of the interest thereon. Under this law the gradual abolishment of the toll roads of Indiana began, and at the present time but 112 miles of such roads are in operation in the State, and that only in the counties along the Ohio River.

Free Gravel or Stone Roads in Indiana.

In 1885 a law was passed providing for the construction of free gravel or stone roads, to be paid for by assessments on all lands lying within two miles of the proposed improvements. Such roads could only be improved upon the petition of a majority of the resident land-holders whose lands, lying within the two-mile limit,

should be thus assessed. The assessments were to be paid in six equal semi-annual installments, and if unpaid when due became a first lien upon the real estate.

In 1893 a second law was passed providing that upon the petition of 50 freeholders in any township, the county commissioners shall submit, by an election, to the voters of said township the question of improving with gravel or stone certain specified roads of the township. If the majority of the voters favor the improvement of such roads, the Board of Commissioners shall issue bonds of the county bearing not over 5 per cent. interest. These bonds shall be in series, one of which shall be payable annually for ten years. To meet the payment of these bonds and the interest thereon as the same shall become due, a special tax is levied upon the property of the township. All roads built under this act shall be free of toll and shall be kept in repair the same as other free gravel roads constructed under the laws of the State.

These two laws, with minor modifications,* are the ones now in force providing for the construction of our free gravel or stone roads. Under them several thousand miles of such roads have been built in the various counties of the State. The majority of these free roads have been built since 1895. Especially is this true of the southern third of Indiana where, previous to that date, a number of the counties had not a single mile of improved roads.

The Supervisor System of Repairing Roads.

Probably the worst feature of the road system of Indiana is one that has been in force since the beginning of the Nineteenth Century, and remains in vogue today, viz., the old method of working out the road tax under supervisors. This forced labor on highways which is demanded of every able-bodied man in the country between the ages of 21 and 50, is a remnant of feudalism which has come down through the ages to the present day. Of it Shaler has well said: "There is probably no other feature in our road system which has so far served to maintain the low state of our American road-making as this 'corvée,' or forced-labor system on the highway. It has bred, in a systematic manner, a shiftless method of work; it has led our people to look upon road-build-

*See section XV, "The Road Laws of Indiana," near the end of this volume.

ing as a nuisance. There is no situation in which the American workman makes so unsatisfactory an appearance as when he is endeavoring to do the least possible amount of labor which is to count as a day's work on the highways of his district."*

As early as 1807 we find on the statute books of Indiana Territory the following: "All male persons of the age of twenty-one years and not exceeding fifty, who have resided thirty days in any township, of any county within this territory, and who are not a county charge, shall be liable yearly and every year, to do and perform any number of days' work, not exceeding twelve, whenever the supervisor of the district in which he resides shall deem it necessary; and if any such resident, having had three days' notice thereof from the supervisor, shall neglect or refuse to attend by himself or substitute to the acceptance of the supervisor, on the day and at the place appointed for working on the public road, with such necessary and common articles of husbandry as the said supervisor shall have directed him to bring, wherewith to labor, or having attended, shall refuse to obey the direction of the supervisor, or shall spend or waste the day in idleness or inattention to the duty assigned him; every such delinquent shall forfeit for every such neglect or refusal, the sum of seventy-five cents, to be recovered at the suit of the supervisor respectively before any Justice of the Peace of the Township.

"If any person or persons working on the highways, or being with them, shall ask any money or drink, or any other reward whatsoever, of any person passing or travelling on the said public road or highway, he shall, for every such offense, pay the sum of one dollar, to be recovered by the supervisor."

In 1814 another statute provided: "That each and every white male person, *sixteen* years of age and upwards, and each and every male person of color, bond or free, *sixteen* years of age and upwards, shall be subject to work on roads and public highways, as is directed by law, except those that shall from time to time be exempted by the courts of common pleas for their respective counties, on account of their entire disability." Later the minimum age limit was restored to 21 years, where it now rests.

The worst feature of the supervisor system is that, as generally practiced, it does not provide for any permanent improvement of

*American Highways, p. 24.

the roads, but only in making temporary repairs to keep them passable in certain seasons of the year. Instead of "working" or frittering away time as is now so commonly done on repairs which amount to little or nothing, it would be far better if one or the other of two methods were adopted, viz.:

1. For the citizens to pay the road tax in cash and let out the contract for keeping the roads of the district in good condition to some one responsible person who shall act under the direction of the township trustee or the road superintendent of the county, and who shall give bond for the faithful performance of his work; or

2. If it is desired to keep up the supervisor system and the "working out" of the tax, the annual work should be done on *some one piece of road* in the district, and it should be graded and graveled or macadamized with the same care as are other free improved gravel or stone roads let out to contractors. In this way a mile or two of good road could annually be built in each district, and the roads thereby permanently improved.

As Mr. George S. Cottman, of Irvington, Indiana, has made a special study of the old Indian trails and early roads of the Territory and State, I asked him to prepare the following brief account of these first byways and highways of our commonwealth, in order that a permanent record of them could be incorporated in the present volume.

SECTION II.

THE FIRST THOROUGHFARES OF INDIANA.

BY GEORGE S. COTTMAN.

THE INDIAN TRAILS.

The first thoroughfares of Indiana, while somewhat remote, perhaps, from present interests, have yet some relation to the after history of the State, besides possessing a certain historic interest of their own. Of these primitive ways for travel and transportation the earliest, long antedating the white man's advent, were the Indian trails—narrow, winding routes beaten by many feet traveling in single file, and akin to the paths made by animals. It should be noted, however, that there was one radical distinction between them and the animal paths, for while the latter had the feeding grounds for their termini, the former, primarily, conducted from abiding place to abiding place. In other words, the human propensity for intercommunication as distinguished from mere gregariousness was revealed by those obscure forest highways, and by virtue of that they were something other than mere random ways—they were a system.

If this system could be restored in a chart we would be surprised, no doubt, to find what a network it formed, reaching over the country in various directions. No such restoration would be possible now, however, for, though there are many allusions to them in our local histories, what information we have about these old trails is scattered, meager and indefinite. About all we know is that the various tribes and bands of Indians occupied each their own territory, usually along the valleys of the principal rivers, and that they visited to and fro more or less for the purposes of counsel or other reasons. Between the tribes of this region little hostility is recorded, and there seems to have been considerable friendly intercourse and formal visiting among them. Following the rivers from town to town, and across from valley to valley, their paths can be traced.

It is likely that the Miami town of Ke-ki-on-ga, where Ft. Wayne now stands, was, from its important command of the Wabash portage, the converging point of many trails, for Little Turtle, in his speech before Anthony Wayne at the treaty of Greenville, refers to the place as "that glorious gate through which all the good words of our chiefs had to pass, from the north to the south, and from the east to the west."

At the junction of Fall Creek and White River, also, several paths seem to have met, by reason, it is said, of a good ford across the river that existed there. Such at least has been affirmed by the late J. H. B. Nowland, a very early pioneer of Indianapolis, who has told the writer definitely of several trails—one from Vincennes, one from the falls of the Ohio, one from the Whitewater, and others from the upper Delaware towns on White River and the Pottawattamie and Miami towns on the Wabash, all of which converged at this point. The one westward from the Whitewater valley ran about where the Pennsylvania railroad now has its right-of-way and that from the Ohio falls paralleled the present Jeffersonville railroad. The latter route was, seemingly, traveled by all the Pottawattamies, Miamis and Delawares of the upper Wabash and White rivers in their excursions to the Kentucky hunting grounds, as, after crossing the above mentioned ford it sent off branches to the towns of those tribes.

Pioneer Traces.

The Indian pathmaker not infrequently marked the way for the white man's thoroughfares, and his work was thus perpetuated in the civilization of his successors. Out of his thorough knowledge of the topography of the country he found out the best routes, not only for his kind of traveling, but for the kind of traveling that was to come after. When James Blake and William Conner viewed, as commissioners, the first road between Indianapolis and Ft. Wayne, they found after leaving White River that they could not improve upon the judgment of the Indians as shown in their old trace.

One of the earliest wagon-ways out of Indianapolis, the old Centerville road, which led to Wayne County before the coming of the National Road, was laid out on the Whitewater trail above re-

ferred to, just south of the Pennsylvania tracks, and mention may be found here and there of other roads that were similarily determined. Moreover, the earliest pioneers were benefited directly by these aboriginal trails, for not only did they first follow them from one place to another through the otherwise trackless wilderness in search of desirable regions, but their rude "traces" for subsequent ingress and egress were frequently but their improvement on the red man's too-narrow footpath. Perhaps it is not venturing too much to say that they were at times an influence in the locating of white settlements. For instance, the first settlers on the spot where Indianapolis now stands were, if tradition is to be trusted, led hither by the Whitewater trail. When the commissioners appointed by the legislature came to locate the capital the presence of the squatters at the mouth of Fall Creek was undoubtedly a factor in determining the choice of that spot; and so it might not be considering too curiously to reason out a relation between this obscure path through the forest primeval and the exact locating of the State's capital with all that that implies.

Before anything like permanent roads could be established a considerable population of settlers had taken up lands in the interior of the State, and there had to be makeshift thoroughfares not only for guidance to various localities, but for the transportation of the immigrant's possessions. These traces, as they were called, were the rudest of forest roads, cleared away sufficiently to permit the passage of the mover's wagons, and marked along the route by "blazing" or marking the trees with an axe. These traces from east and south, with their various branches leading to this or that settlement, were well known to the immigrants in their day, but, like the Indian trails, they are long since obliterated, and, for the most part, only vague allusions to them are to be found in local histories. Of at least two of them, however, some record has been preserved, and these are of special interest because they were the trunk lines, so to speak, over which the first waves of immigration found their way in to people the central portion of the State. They were known respectively as the Berry and Whetzel traces.

The Berry trace, marked out by a Captain John Berry, or, as Judge Bânta gives it, Richard Berry, joined and followed the Ohio Falls Indian trail above mentioned, which crossed White River at Fall Creek. It was the chief line of travel from the

south. The best account of this route is given by Mr. Nowland in describing the journey of his family to Indianapolis from Kentucky in 1820. According to him it began at Napoleon, Ripley County (south of that being settled country), and thence ran almost west to a point on Flatrock River about nine miles north of where Columbus now stands. At the end of this stage of perhaps thirty miles stood the first house after leaving Napoleon. Then the trace turned north to follow the said Indian trail, and this, with two or three more cabins on the way, brought them to the embryo capital. Further information concerning the pioneer whose name has been perpetuated by this old trace the present writer has been unable to glean.

What was known as the Whetzel trace was made in 1818 by Jacob Whetzel, one of the four brothers famous in the annals of Indian warfare. It afforded ingress from the already settled Whitewater region on the east, and is also described by Mr. Nowland. It began, he tells us, in Franklin county, somewhere near where Laurel now stands, ran west till it struck the Flatrock River seven miles below the site of Rushville, thence to the Blue River where Marion and Shelby counties join, thence west to the bluffs of White River. This was the most notable of all these early traces, for by it, we are told, hundreds of immigrants came to settle Shelby, Morgan, Johnson and Marion counties. Those bound for the new capital followed it till it reached the Berry trace, then turned north on the latter, and many of the first families of Indianapolis were beholden to the sturdy old Indian fighter for his unrequited service, which, indeed, he had performed at no small cost to himself. He and his son Cyrus, with the help of four good axemen, cleared the way for "a width sufficient to admit the passage of a team," as Judge Banta tells us, through vast stretches of tangled forest and swamp lands where of nights they had to build up brush piles to sleep on. In 1825 a petition, presented to the legislature by William Conner in behalf of Jacob Whetzel, prayed compensation for the cutting of this road, the eastern terminus being there designated as "Summerset." Said petition, along with various others, was referred to a committee on roads, which reported back that, "in the opinion of the committee, it would be inexpedient to legislate on any of the aforesaid petitions." (See House Journal, 1825, pp. 89 and 170.)

At the intersection of the Whetzel and Berry traces (about two miles southwest of Greenwood, in Johnson county) a man named Daniel Loper "squatted" and offered entertainment, after a fashion, to incoming travelers. Before long, however, a fellow named Nathan Bell ousted Loper by falsely representing himself as the legal purchaser of the land, and next took possession of the desirable point, where for a good while he kept a disreputable sort of a place, surrounded by "his clan of adherents, generally bold, bad men," the history of which place and clan would, according to Judge Franklin Hardin, a reminiscent of Johnson County, "make a large volume." Loper moved along the trace some miles farther east, and, still bent on "entertaining," pitched his shanty on Hurricane Creek, where was the first good water and the first good camping place after coming out of the swamps. He staid there a couple of years, then went none knew whither, but his pole cabin, long known as Loper's, continued to be a favorite halting place for incoming travelers, the dilapidated hut being facetiously dubbed the "Emigrant's Hotel." Judge Hardin describes the place as several acres trodden over by men and animals, with many inclosures of poles and brush put up by sojourners to keep their stock from wandering.

By 1826 Whetzel's trace was no longer used, at least at the west end, being impeded with fallen trees. By this time, too, many State roads were being opened into the interior, and the need for the first traces ceased to exist. Not having a legalized right-of-way it was in time, of course, taken up by private owners as the land was entered, and so has long since lost the last evidence of its identity.

The First Road System.

It was not until four years after Indiana had been admitted as a State that any definite system of roads was projected within her borders. Prior to that general laws had been framed touching the opening of highways, for with the first tides of emigration, of course, came the question of intercommunication; but they provided only for the opening of local roads on petition. In those first years there was little pressing need for other than local roads, for Indiana was, for the most part, strung along the Ohio and

Wabash rivers, which were the generally used, natural highways. Versailles, Vernon and Brownstown, but a few miles back from the Ohio, were, until 1820, on the extreme frontier, the vast country to the north and west of them being an unbroken wilderness, and the principal centers were contiguous to one or the other of the two rivers named.

In 1820, however, there arose new reasons for extensive road making. The great tract known as the "New Purchase," comprising all the central portion of the State and as far north as the upper Wabash, was thrown open to settlers in that year. Somewhere in the heart of this territory the seat of government was to be located at once, and it was obvious that the capital and the settlers who would people the newly acquired tract must have some way of reaching the older parts of the country and the world's markets. This would seem to be the rational explanation of the sudden legislation on State roads that appears in the statutes at this time. In 1820 not less than twenty-six roads were projected, and as many sets of commissioners appointed to view the lands and mark out the routes. The roads not only connected the older towns of the State but extended into the interior. Five were to lead to the proposed capital, and one was from Lawrenceburg to Winchester, this latter being by a subsequent act extended to Fort Wayne. During the next ten years there was repeated and lengthy legislation on this subject of State roads, showing the paramount importance of highways in the early days of the new commonwealth. Many other roads were added to the original system, some were relocated, and there were various modifications. In the main, however, the first ideas were carried out, and on a road map of 1835, now existing, at least two-thirds of the State is pretty well criss-crossed with highways other than the local or county roads.

The revenue and labor for the opening and maintaining of these roads were derived from three distinct sources. The first was known as the three per cent. fund, and was a donation from the general government. Out of the sale of public lands five per cent. was set aside for purposes of internal improvement. Of this two per cent. was to be expended by the United States on works of general benefit—such, for example, as the National road

—and the remaining three per cent. was given to the State for improvements within her borders. Into this fund there was paid, altogether, the sum of $575,547.75.* A special agent was appointed for disbursing the fund, and his duties were defined at length.

Another internal revenue was derived from a "road tax" levied upon real estate. Farm lands were assessed "an amount equal to half the amount of State tax," and town lots "an amount equal to half the county tax." Nonresident land owners were assessed an amount equal to both half the State and half the county tax. Such road tax the landowner was entitled to discharge in work on the roads (see acts of 1825).

The third source of maintenance was a labor requirement, which made it incumbent on all male inhabitants between the ages of twenty-one and fifty, except preachers and certain other exempts, to work on the roads two days in each year, when called out, or pay an equivalent thereof. In the New Purchase, where the labor necessary was still greater than farther south, the demand was for four days each year, but this provision was repealed in 1827.

But establishing roads by legislative enactment was only a first and very inadequate step toward easy travel and transportation. Moreover, it was not altogether a satisfactory first step, for then, as now, there was much log-rolling, self-seeking and lack of economy in public works, and in Governor Ray's message of 1825 the question was raised as to whether the large expenditures "have answered the expectations of the public"—whether they had not been used extravagantly in the employment of too many commissioners, in the opening of useless roads, and in suffering roads to become useless by a second growth and the failure to keep in repair. Aside from this, after the highways were cut out and the labor of the population expended upon them, they were hardly more practicable than the drift-choked streams which were fondly regarded as navigable.

Of the atrocious character of those early highways much has been said, and yet the subject, seemingly, has never been given justice. From the hills of the southern counties to the prairies

*Elbert Jay Benton in "The Wabash Trade Route," p. 41.

beyond the Wabash the State was, for the most part, a level plain covered with a forest that shut out the sun from the rank mold, and this, like a sponge, held the accumulated waters. Vast areas were nothing but swamps, which the streams never fully drained.* Most of the year a journey over the roads was simply a slow, laborious wallowing through mud; the bogs were passable only by the use of "corduroy," and this corduroy of poles laid side by side for miles not infrequently had to be weighted down with dirt to prevent floating off when the swamp waters rose. In a book called "The New Purchase," which purports to depict life in central Indiana in the early twenties, the wagon trip to Bloomington is described in the author's peculiar, half-intelligible style. He speaks of the country as "buttermilk land," "mash land," "rooty and snaggy land," with mudholes and quicksands and corduroys, "woven single and double twill," and there are fords "with and without bottom." In the early spring, he says, the streams were brim full, "creeks turned to rivers, rivers to lakes, and lakes to bigger ones, and traveling by land becomes traveling by mud and water." As one proceeded he must tack to right and left, not to find the road, but to get out of it and find places where the mud was "thick enough to bear." The way was a "most ill-looking, dark-colored morass, enlivened by streams of purer mud (the roads) crossing at right angles," and these streams were "thick-set with stumps cut just low enough for wagons to straddle." Innumerable stubs of saplings, sharpened like spears by being shorn off obliquely, waited to impale the unlucky traveler who might be pitched out upon them, and the probability of such accident was considerable as the lumbering wagon plunged over a succession of ruts and roots, describing an "exhilarating seesaw with the most astonishing alternation of plunge, creak and splash." Ever and anon the brimming streams had to be crossed, sometimes by unsafe fording and sometimes by rude ferries. In the latter case the ferrykeeper was apt to be off at work somewhere in his clearing,

*Mr. William Butler, a pioneer of Southern Indiana, has told the present writer of a trip he made to Indianapolis in the thirties. He stopped over night with a settler in Johnson County, and, inquiring as to the country east of them, was told that there was no other residence in that direction for thirty miles. "And what's more, there never will be," the informant added, his reason being that the submerged land was irreclaimable. It may be remarked, incidentally, that the swamp in question has long ago been converted into fine farms.

and the traveler had to "halloo the ferry" till he could make himself heard.

This seemingly exaggerated account of the author might be confirmed by many references, but three or four brief anecdotes which the writer has gleaned at first-hand from pioneers will do. The first of these, told by the late J. H. B. Nowland, of Indianapolis, is that once, when on his way by stage from Madison to Indianapolis, he was upset in the middle of a swollen stream, and in the effort to save his life he lost his coat, which, with thirty or forty dollars in the pocket, was swept away. Another is that of Mr. George W. Julian, who, when a child, traveled by wagon from the Wea plains on the Wabash to Wayne County. Crossing a stream, the water proved unexpectedly deep and the bank so precipitous that the horses lost their footing and were forced entirely under the flood by the descending wagon. Similar to this was an experience of Mr. William Shimer, of Irvington. When his family moved to Marion County they entered a stream by a descent so steep that a great feather bed stowed in the front of the wagon rolled out and covered the driver. Mr. Nowland also relates in his book of reminiscences that a migratory wag once wrote these lines in the register book of a Franklin tavern:

"The roads are impassable--hardly jackassable;
I think those that travel 'em should turn out and gravel 'em."

Such were the early thoroughfares of Indiana, and these, with the exception of an uncertain outlet by the larger streams, were the only means of travel and transportation for the greater part of the State with its growing population. That the character of the thoroughfares impeded growth, handicapped commerce and held in check the influences that are essential to development is very obvious to the student of that development within our borders. The difficulties that were overcome and the building up of the commonwealth in spite of such handicap is an evidence of the sturdiness of the stock that peopled the State.

Road Improvement.

As the establishment of roads in the beginning was an absolute necessity to the settlement of the country, so the improvement of those roads, regardless of other systems of transportation, was essential to its welfare. Given rivers, canals and railroads, and yet the problem of getting the produce of the land to these arteries confronted a vast proportion of the population—particularly the farming element. We have already noted the difficulties that attended the original opening of the roads and their limited usefulness when opened. The improvements of the earlier day, despite the funds expended upon them and the unpaid labor of practically the whole male population, amounted to but little toward making the highways travelable except at certain seasons, and consisted almost wholly of cleaning the way, scraping up into the middle dirt that became mud when it got wet, and the laying of "corduroy" or supporting poles across the bottomless places. Even at the present day, with the country open, well-drained and comparatively dry, the ordinary dirt road is a vexatious makeshift, and when the forest-encumbered land was saturated like a sponge for the larger part of the year, its drawbacks were tenfold. The only really serviceable material that was utilized at all was macadam, or broken stone, but the inaccessibility of this, except in a comparatively few localities, made it wholly impracticable over a major part of the State's area, though certain highways included in the internal improvement scheme were to be built of it.

How seriously road improvement affected public welfare is evidenced by our legislation. From the road law of 1820, which authorized the opening up of an extensive system of thoroughfares, on through the decades, there was scarcely a session but road laws were enacted, adding to, modifying or repealing preceding statutes. It is, perhaps, an added argument against paternalism that little or no really effective improvement was accomplished until the State's efforts were succeeded by private enterprise. This change was contemporaneous with the introduction of the plank road idea. This innovation appears to have originated in Russia, to have found its way thence into Canada, and from there into parts of the United States lying contiguous to Canada. In a country where timber was not merely abundant, but an actual encum-

brance, the conversion of this timber into a solid road as smooth as a floor was a captivating proposition, and the fever caught and spread. In no place was there better reason for its spreading than in Indiana, and accordingly for nearly ten years (through the fifties) we had the plank road era. The promise of immediate returns was, presumably, sufficient to attract capital, and the State very wisely handed over the new movement to the capitalists. From 1848 we find laws authorizing corporations to take possession of the existing roads, to convert them into plank roads, and to erect and maintain toll houses for revenue along the same. In 1850 one of these companies, organized to build a plank road from New Harmony to Mt. Vernon, in Posey County, sent Robert Dale Owen to western New York to investigate the roads already in operation there, and the result was the publication of a small book containing a mass of information upon the subject.* There were various widths and methods of laying in the construction of these roads, but that recommended by Owen was eight feet wide, formed of planks two and a half to four inches thick laid crosswise on long mud sills, and well spiked down. The cost of this material he estimated at $938.08 to $1,689.60 per mile, according to thickness of planks. The labor item is a party of twelve or fourteen hands with teams for ploughing, scraping, rolling, etc., and these should lay from thirty to forty rods per day, at an expense of perhaps $200 per mile. The approximate total cost of a road built of three-inch white oak planks is given as $2,000 per mile.

While Owen, with the bias of an advocate, perhaps, figures that a white oak road would do good service for at least twelve years, as a matter of fact those constructed in this State would seem to be much shorter of life. Within ten years the decadence had plainly set in, for a law of 1859 prohibits the collection of tolls on roads that are not kept up, and about this time plank road legislation disappears from the statutes. The difficulty was not only decay, but the warping and working loose of the plnks.

In 1858 we find the first statutory mention of gravel roads, and the introduction of this material, presumably about that time, was the beginning of a possible permanent excellence. Why it was not earlier used is not easy to learn, but it is probable that prior

*Owen on "Plank Roads," New Albany, 1850.

to the clearing up of the country when the drift-choked, forest-environed streams flowed with a fuller volume, gravel bars were at once much less in evidence, and much less accessible than at a later day. Construction with this new material went on under private enterprise, the State became well traversed with toll roads, and the ubiquitous little toll house, with its long sweep pole, is still fresh in the memories of most of us.

The next turn in legislation was a provision (as early as 1879) for the county control of free turnpikes and the authorization of tax levies for that purpose. Under these laws the improved roads have, one by one, been bought up by the several counties, and the abolishment of the tollgate is becoming general.

The Michigan Road.

The story of early roads in Indiana and the large space they occupied in the public interest would be incomplete without at least a passing account of two enterprises of particular magnitude that, in their inception and construction, stood apart from the ordinary State and county roads. These were the National and Michigan roads. The first has already been treated of in the pages preceding this article. This, a national work, cutting straight through the State from east to west, bisected it into north and south halves, while the other, connecting Lake Michigan, at Michigan City, with the Ohio River at Madison, traversed the various sections north and south.

The Michigan road is, in a sense, a monument to the white man's shrewdness in his dealings with the red man. By the Mississinewa treaty of 1826 a goodly portion of northern Indiana was transferred to the United States for a price that would at this day, perhaps, be quivalent to a few city lots, and the following clear gift, specified in Article II of the treaty, was secured by way of good measure. The article reads:

"As an evidence of the attachment which the Pottawattamie tribe feel toward the American people, and particularly to the soil of Indiana, and with a view to demonstrate their liberality and benefit themselves by creating facilities for traveling and increasing the value of their remaining country, the said tribe do hereby cede to the United States a strip of land, connecting at Lake Mich-

igan and running thence to the Wabash River, one hundred feet wide, for a road; and also one section of good land contiguous to said road for each mile of the same, and also for each mile of a road from termination thereof, through Indianapolis, to some convenient point on the Ohio River. And the General Assembly of the State of Indiana shall have a right to locate the said road and apply the said sections, or the proceeds thereof, to the making of the same, or any part thereof; and the said road shall be at their sole disposal."

The hand of the beneficiaries would seem to be very plain in this. Why the Pottawattamie Indians should feel an especial attachment to the American people, who were gradualy pushing them off the earth, and how they were to be benefited by an inlet, the sole purpose of which was to facilitate the oncoming of the usurpers, and how, by the light of previous land transfers, the value of their remaining country would be enhanced to them, makes a series of queries that need not be discussed here. Suffice it to say that from this gift of land the Michigan road was built, the sales of land about balancing the cost of the road.* The work, begun in 1828, was practically a decade in the building, and during that period occupied a prominent place in the public interest, as revealed by the papers of the time and by its frequent recurrence in the Governor's Messages and in legislation. Like the National road, its chief service, beside the local one, was as a route for immigration, and as such it was an important thoroughfare in the peopling of the Wabash Valley and the territory beyond, untill the coming of the Wabash & Erie Canal, when its usefulness lapsed. This applies particularly to the northern portion of the road. Between Indianapolis and Madison, prior to the establishment of the Madison railroad, it was an important thoroughfare of traffic, affording the principal outlet for the capital.

The general direction of the Michigan road is as follows: Beginning at Trail Creek, on Lake Michigan, the road runs easterly to the southern bend of the St. Joseph River; thence southward to the Wabash River, which it crosses; thence to Indianapolis; thence southeast to Greensburg; thence south again to Madison.

*The total expenditure on the road up to 1840, when it ceased to appear in the Auditor's reports, is given as $242,008.04, and the receipts as $241,331.89, with several hundreds of acres of land still to be sold.

SECTION III.

ROAD MATERIALS IN GENERAL.

BY W. S. BLATCHLEY.

Good roads can only be built with good materials. Though road making has gone on for thousands of years, mankind has not yet fully learned the importance of the above statement. As a consequence millions of dollars have been and are being spent in constructing highways which, at the best, were or are only temporary makeshifts. During the past summer the writer saw roads in several of the counties of southern Indiana which had been recently built at a cost of $1,500 or more a mile, on which the material used was of such a nature that the road will not last five years, without a heavy annual expense for repairs. Other roads have been built in the State for the same price per mile which have been in use thirty or more years, with little annual outlay for repairs, and which are today in good condition. The great difference is due to the character of the material used in the surfacing of the roads.

According to the amount and kind of traffic to which roads are subjected, they may be divided into four groups. These, in an ascending order, are: (a) *Neighborhood* or *country roads,* which serve limited districts and connect or merge into the more important highways. Since the traffic over them is at no season very heavy, the choice of materials need not be so exacting as over those more extensively traveled. (b) *Highways,* or the main arteries of a country district, over which the traffic is much heavier, as these roads usually connect the principal towns or county seats one with another. (c) *Suburban roads,* as those found in the suburbs of a city or the main streets of country towns. (d) *City streets,* where the traffic is so great that paving brick, stone, wooden blocks or asphalt are necessary. Such streets will not be considered in this connection.*

*I regard vitrified brick made of either the Carboniferous or the Knobstone shales of Indiana as the best paving material for city streets. See the article entitled "The Formation of Brick Pavements," pp. 539-561, in the 29th (1904) Report of this Department.

Forces Destructive to Improved Roads.

The essential qualities of a good road surface are hardness and smoothness. Contending at all times with these qualities and tending to weaken or destroy them are two great classes of forces, viz.: (a) The wear and tear of travel. (b) The forces of Nature. The travel on a road tends to destroy it in a number of ways, the principal ones of which are: "(1) by the blows of the horses' feet; (2) by the blows of the wheels, for no road is so smooth that the wheels do not at times strike against, and at times fall from, slight projections and thus produce blows against the road; (3) by the action of the horses' feet in pulling or holding back, tending to pull the stones out of place; (4) by friction of the wheels, especially when brakes are used; and (5) by the pressure on the road due to the weight of the vehicle and of the horses. It is evident that some of these causes (3, 4) tend to destroy the general cohesion of the road and to loosen the stones; others (1, 2, 4) tend to break up the pieces of stone themselves into smaller particles and to grind them into dust; the effect of pressure (5) is probably beneficial to a well made stone road, as it tends to consolidate it; but a soft road, or one with too thin a stone covering, is terribly cut up by the pressure of the wheels."*

The natural forces which tend to wear or destroy roads are principally winds, heavy rains, frost and great changes of temperature.

Winds, especially the strong southwest ones, so prevalent in Indiana in summer, tend to sweep away all the fine dust ground up by travel, and so keep it from cementing and forming that waterproof coating which is so essential to the life of a stone road. These winds are especially effective on a new road during long droughts, when the road surface becomes very dry.

Heavy rains also wash out the dust and small particles which hold the stones together. Oftentimes, when the side ditches are not kept open, the rushing water flows down the middle or sides of the road with such force as to carry away part of the stone covering and leave great ruts in the road.

Frost, with its well known heaving action, and the subsequent crumbling when the thaw comes, is one of the most harmful of forces acting upon roads, especially those with wet foundations.

*Reid.—Md. Geol. Surv., III, 1899, 317.

It not only disturbs the whole road structure, but tends to force up the larger stones through the macadam or gravel and so make the surface rough and uneven.

Great and sudden *changes of temperature*, so prevalent in our Indiana climate, produce alternate contractions and expansions of the surface covering, which often break the bonds holding together the broken stone and so lead to the rapid wear of the road.

Broken Stone as a Road Material.

For the traffic of suburban roads and highways experience has shown that the best material is broken stone put on after the method of Macadam. As will be noted later, such roads should not be less than twelve nor more than fifteen feet in width. On them a tough rock of a high cementing value is necessary to withstand the heavy traffic.

"The practice of using too soft, too brittle, or rotten material on such roads cannot be too severely condemned. Some people seem to think that if a stone quarries easily, breaks easily and packs readily, it is the very best stone for road building. This practice, together with that of placing the material on unimproved foundations and leaving it thus for traffic to consolidate, has done a great deal to destroy the confidence of many people in stone roads. There is no reason in the world why a road should not last for ages if it is built of good material and kept in proper repair. If this is not done, the money spent is more than wasted. It is more economical, as a rule, to bring good materials a long distance by rail or water than to employ inferior ones procured close at hand." In many cases, however, the selection of a material for road making is determined more by its cheapness and convenience of location than by any properties of fitness or durability which it may possess.

Necessary Physcial Properties of Rock Used for Macadam.

Any stone chosen as a road metal should possess certain physical properties which will enable it to best withstand the action of the destructive forces above mentioned. Experience has shown that the most important of these properties are hardness, toughness and

cementing or binding power. Others, less important, are power of absorption and density.

By *hardness* is meant the power possessed by a rock to resist the wearing action caused by the abrasion of wheels and horses' feet. A rock for a road of light or medium traffic should not be too hard, else the amount of fine dust worn off would be carried away by the wind and rain as fast as produced and none would be left to supply a binding material.

Toughness is the adhesion between the crystals and fine particles of rock which gives it power to resist fracture when subjected to the blows of traffic. It is closely allied to, yet distinct from, hardness, and can, in a measure, make up for a deficiency in hardness. For example, hardness may be likened to the resistance offered by a rock to the grinding of an emery wheel; toughness, the resistance to fracture when struck with a hammer.

Cementing or binding power is the property possessed by the dust or fine particles of a rock which causes it, after wetting, to act as a cement, thus binding the coarser fragments together and forming a smooth, impervious shell or cover over the surface. "Such a shell, formed by a rock of high cementing value, protects the underlying material from wear and acts as a cushion to the blows from horses' feet, and at the same time resists the waste of material caused by wind and rain, and preserves the foundation by shedding the surface water. Binding power is thus, probably, the most important property to be sought for in a road-building rock, as its presence is always necessary for the best results. The hardness and toughness of the binder surface, more than of the rock itself, represents the hardness and toughness of the road, for if the weight of traffic is sufficient to destroy the bond of cementation of the surface, the stones below are soon loosened and forced out of place. When there is an absence of binding material, which often occurs when the rock is too hard for the traffic to which it is subjected, the road soon loosens or ravels."*

Every stone road, unless properly built with small stones and just enough binding material to fill the voids, presents a honeycombed appearance. In fact, a measure containing two cubic feet of broken stone will hold, in addition, one cubic foot of water; and

*Page.—Year Book of Agriculture, 1900, p. 351.

a cubic yard of broken macadam will weigh just about one-half as much as a solid cubic yard of the same kind of stone.

Binding material to produce the best results should be equal in hardness and toughness with the road stone; the best results are therefore obtained by using screenings or spalls from the broken stone used. Coarse sand or gravel can sometimes be used with impunity as a binder, but the wisdom of using loam or clay is very much questioned. When the latter material is used as a binder the road is apt to become very dusty in dry weather, and sticky, muddy and rutty in wet weather.

The power of absorbing moisture from the atmosphere is possessed by some rocks, especially limestones. In dry climates or in excessive periods of drought this property becomes valuable, in that the cementation of the dust is, in a large measure, dependent upon it.

The *specific gravity* or relative weight of a rock is also of importance, as the heavier it is the better it stays in place and the less readily will the small particles, into which the surface rock is broken by travel, be blown or washed away.

In selecting any rock or other material for road making purposes, certain local conditions should always be taken into consideration. These are principally the annual rainfall, the average winter temperature, the character of prevailing winds, the grades and the volume and character of the traffic that is to pass over the road. The climatic conditions are readily obtained from the weather bureau, and a satisfactory record of the volume and character of the traffic can be made by any competent person living in view of the road.

Kinds of Rocks Used for Road Making Materials.

The more common rocks used for road making purposes in the United States, named in the order of their fitness, are as follows: Trap, syenite, granite, chert, limestone, quartzites, sandstone and shale.

Trap rocks, or basalts, as they are often called, are igneous in nature, i. e., were once in a molten or fluid state, and while in that condition were forced up through fissures in the sedimentary rocks into the positions they now occupy. There are many varieties of

these, the more common of which are gabbro, peridotite, diorite and diabase. During the process of cooling and consolidation they became very compact. They are, for that reason, solid and elastic, and on account of their resistance to wear and their fairly good cementing qualities they rank among the best of road making materials, being especially suited for roads which have a heavy traffic. Where they occur they generally resist decay to such an extent that they often project above the surface, while the softer rocks on either side have been worn away by erosion.

Trap rocks are found abundantly over most of New England and in the upland districts of New Jersey, Maryland and Pennsylvania. In these regions they are used extensively for macadam purposes. Between the Appalachian Mountains and the Mississippi River they are very rare, except in northern Michigan, where dikes of such rock are common. Boulders from these dikes are scattered over the northern two-thirds of Indiana, but other than these boulders, trap rocks do not occur in the State.

Syenite, granite and *gneiss* are closely related forms of igneous rocks, which are, in general, well fitted for road material. However, the large percentage of quartz which they contain renders their cementing qualities rather low and makes them less durable under heavy traffic than the traps. Having a closely related origin they occupy the same general areas as the trap rocks, and are usually much more abundant. In Indiana they occur only in the form of numerous boulders distributed irregularly over the drift covered area of the State.

Cherts are impure, dull colored, massive forms of quartz or siliceous rocks. They are very hard and are, therefore, usually lacking in toughness and in cementing power. Those which are tough enough to resist the action of hoofs and wheels make a good macadam material. They are beginning to be used extensively for this purpose in Virginia, Georgia and other southern States. In southern Indiana they occur alternating with the upper layers of the Mitchell and other limestones, and will be mentioned under another heading.

Limestones are sedimentary rocks which usually have high cementing power, but are softer and less tough than the rocks previously mentioned. Where found in thin layers (2 inches to 3

feet) with little sign of crystallization, they are usually tough enough to withstand the wear of country roads and highways. The thicker bedded, more crystalline forms are usually too soft for road building. They bind easily and make a smooth surface quickly, but are too weak for heavy loads. They are soon ground into powder which washes and blows away very rapidly. Where abundant, however, with other road material lacking, fairly substantial roads can be made of these softer limestones by covering the surface with three or four inches of creek gravel, or with nodules of iron ore. Some of the better roads of southern Indiana have been recently built in this manner. Limestones suitable for road building are abundant in many parts of the southern two-thirds of Indiana, and the great majority of the stone roads of the State have been constructed of this material.

Quartzites are forms of siliceous rocks which are usually very hard, brittle and have a low cementing power. They occur usually in mountainous regions and in Indiana are represented only among the boulders. As road materials they are failures, as their parts do not bind together and are soon reduced to sand.

Sandstone is only an aggregation of small particles of quartz or sand cemented together, often rather loosely. They are utterly useless for road-building, as they are without binding value and the fragments quickly go to pieces under the tread of horse and wheel. Sandstone has been recently used in some of the counties of southwestern Indiana as the base or foundation of a number of roads. Over it has been spread a few inches of gravel, or, in some instances, broken limestone. Such roads, under anything like a heavy traffic, will be found short lived, and hardly worth the building.

Clay slate or shale, when used raw or unburned, makes a smooth surface, but one which usually softens rapidly and goes to pieces when wet. Most shales have but slight binding value and their fragments quickly grind into mud. Their value as a road building material is therefore less than any other of our common rocks, unless it be sandstone. However, one of the Devonian shales, which occurs abundantly in certain portions of Indiana, contains enough binding material to cause it to pack and form a fairly solid and lasting road.

Gravel as a Road Material.

Next to broken stone, and better than some of that in use, ranks gravel as a road material. Where beds of good gravel are available it is the simplest, cheapest and most effective of road materials for neighborhood or country roads that have a comparatively light traffic. On roads with a heavy traffic, a macadam surface of broken stone will be found cheaper in the long run, provided the stone can be found within reasonable distance, so that its transportation will not make the first cost prohibitive.

In general, gravel may be defined as a mass of small, more or less rounded fragments of stone which have been broken out and shaped by the action of water or of ice. The particles represent the hardest parts of the ledges or layers of bed rock from which they were originally separated. Since the gravels have been formed from various ledges of rock by the action of frost and other agents of decay, and have been borne to their present resting places either by ice or water, or both, the range in the quality of the material is necessarily great. The selecting of the proper material is, therefore, the most important matter to be considered in the building of a gravel road.

Where possible, a good "binding gravel" should be chosen; i. e., one that contains sufficient iron, lime, clay or other cementing material to cause the pebbles or particles of gravel to pack or bind together under traffic. River gravels, which are usually composed of rounded water-worn pebbles, are inferior to many pit gravels for surfacing roads. The small stones, having no sharp edges or angular projections, easily move or slide one against another, and being usually lacking in cementing material, they will not bind, but turn freely, thus causing the whole surface to remain loose for a long period. The best gravel for road building stands perpendicular in the bank; that is, when the pit has been opened up the remainder stands compact and firm and can not be dislodged except by use of the pick, and when it gives way falls in great chunks or solid masses. Such material usually contains tough angular gravel with just enough cementing properties to enable it to readily pack and consolidate.

To get the best results from gravel where it is formed of various sized fragments it should be screened, all pieces over two inches in

size being rejected. Gravel mixed with a large percentage of sand or clayey matter is of little use except when so screened. For this purpose two screens are necessary, through which the gravel should be thrown. The meshes of one screen should be one and a half or two inches in diameter, while the meshes of the other should be three-fourths of an inch. All pebbles which will not go through the one and a half inch meshes should be rejected or broken so that they will go through. All material which sifts through the three-fourths inch meshes should be rejected for the road, but may be used in making side paths. The excellent road which can be built from materials prepared in this way is so far superior to the one made of the natural clayey material that the expense and trouble of sifting is many times repaid.

Since the principal road material in a large portion of northern Indiana is either drift or stream gravel I quote the following paragraphs from Shaler relative to the screening of gravel in quantity, and also the comparative cost of gravel roads:

"Where, as can often be done, the gravel may be lifted by steam shovels and, in dry weather at least, pass directly through rotating drum screens, the cost of the work, based on the rate of delivery from the shovel, including the excavating, is not likely to exceed five or ten cents per ton. Where an objectionably large amount of clay is mingled with the pebbly material it may be necessary to effect its separation by water. This can be accomplished in ordinary 'log-washers,' consisting essentially of a long trough with a rotating cylinder armed with plates, which stirs the material as water passes through it, the plates being set at such an angle that the gravel is pushed forward toward the point of discharge. With a properly organized equipment the cost of this work per ton of gravel, where the useful part of the mass is as much as one-third of the whole, need not exceed, if the work is conducted on the scale of 200 tons production per diem, about 40 cents per ton. This, however, does not include the cost of excavation, a rate which will still leave the cost of gravel much less than that which is incurred in producing a like amount of broken stone where the material has to be taken from a solid ledge."*

"Where gravel of good quality for road building can be found near the road, the first cost of a hardened way, so far as the pave-

*American Highways, p. 68.

ment is concerned, need not exceed one-half, and may not amount to one-fourth, that required for a road made of broken stone. This lessened cost is due to the fact that the expense of breaking the material is spared. Moreover, the distance to which the gravel has to be hauled is often less. It is, however, to be noted that graveled ways are certain to prove somewhat more troublesome in regard to repairs, and are likely in a term of years to be more costly to keep in order than those which are macadamized. Nevertheless, as before remarked, in determining as to the manner in which a country road is to be improved, care should be taken to ascertain whether the conditions do not admit of its being covered with this gravel. If the need of the traffic can be met by such a road and the material for use is at hand, the capitalized cost, including the expenses of repairs made with all desirable frequency and care, probably need not be greater than one-half that of the dearer form of construction with broken stone.

"The peculiar advantage of gravel roads, as regards their cost, is that they require no investment of money in crushers or other costly machinery. There is, it is true, a certain advantage in rolling the surface of the bed before the gravel is applied in order to bring it into shape for use. All the needed compacting may be effected by horse-rollers. No use of the steam roller within the practicable limits of its continuance will cause gravel to 'come down' in the manner of ordinary broken stone. This pressure, in the present state of the art, had best be left to the action of the vehicles. Therefore, once again it is urged that, while the pavement of broken stone is, in most instances, the best and in many cases is indispensable, the fitness of any road for the service of a community should be made the subject of careful inquiry before adopting the costlier method of construction."*

The Testing of Road Materials.

There are but two ways in which the value of any material for road construction can be accurately determined. "One way, and beyond all doubt the surest, is to build sample roads of all the rocks available in a locality, to measure the traffic and wear to which they are subjected, and keep an accurate account of the cost both

*Loc. Cit., 218.

of construction and annual repairs for each. By this method actual results are obtained, but it has grave and obvious disadvantages. It is very costly (especially so when the results are negative), and it requires so great a lapse of time before results are obtained that it can not be considered a practical method when macadam roads are first being built in a locality. Further than this, results thus obtained are not applicable to other roads and materials. Such a method, while excellent in its results, can only be adopted by communities which can afford the necessary time and money, and is entirely inadequate for general use.

"The other method is to make laboratory tests of the physical properties of available rocks in a locality, study the conditions obtaining on the particular road that is to be built, and then select the material that best suits the conditions. This method has the advantages of giving speedy results and of being inexpensive, and as far as the results of laboratory tests have been compared with the results of actual practice, they have been found to agree."*

The Road Material Laboratory of the U. S. Department of Agriculture was established in December, 1900. It contains all the necessary appliances for making tests of road materials and for investigating the more important problems connected with the work. On taking up the subject of the available road materials in the different counties of Indiana, the writer put himself in correspondence with Mr. L. W. Page, the Director of the Office of Public Roads at Washington, who kindly offered to make tests of any material sent in. Advantage was taken of this offer and 74 samples of limestone and six of gravel were collected in different parts of the State and sent to Washington for testing. The results of the tests of each sample are given on subsequent pages, in connection with the description of the deposit of same under the different county headings. These results will also be found in tabulated form at the end of Section V.

In order that the tests to which the samples have been subjected in the laboratory may be the better understood, I have thought it best to incorporate herewith the following condensed account of the objects sought and the methods used in the Road Laboratory at Washington. This information is mainly taken from

*L. W. Page, in Year Book Dept. Agr. for 1900, p. 355.

Bulletin No. 79, Bureau of Chemistry, U. S. Department of Agriculture.*

Important Physical and Mechanical Properties of Road Materials.

"There are three chief properties essential to good road materials, and only these will be considered here. They are hardness, toughness and cementing or binding power. Although these properties, at least hardness and toughness, have long been recognized by those familiar with the subject, yet they have never been properly defined and the terms have been very much confused. This is not at all surprising, for hardness and toughness are closely related. It would be well, therefore, to define these terms from the road maker's standpoint before going further.

"*Hardness* may be defined as the resistance which a road material offers to the displacement of its particles by friction. The measure of hardness will be, inversely, as the loss of weight arising from the scoring by an abrasive agent. Only one test has yet been devised for determining the hardness of road materials, and that, the writer believes, gives the value of this property as understood by road builders in a satisfactory manner. This is the Dorry test of the French School of Roads and Bridges which consists in grinding specimens with sand of a standard size and quality. This method of grinding with a powder has the advantage of having been used as a test for hardness by a number of the most able students of the subject, and at the same time valuable results have been obtained from it on the very class of materials in which we are most interested.

"*Toughness.* In consideration of road materials toughness is understood to mean the power possessed by a material to resist fracture under impact. As the surface of a road is continually subjected to the pounding of traffic, it can be seen that toughness is an important property from the standpoint of the road builder. From the laboratory standpoint the problem is not altogether a simple one, and considerable difficulty has been found in designing

*This bulletin is entitled "The Testing of Road Materials, including the Methods Used and the Results Obtained in the Road Material Laboratory, in Collaboration with the Office of Public Road Inquiries." By Logan Waller Page, Chief Road Material Laboratory, with the co-operation of Allerton S. Cushman, Chemist, Road Material Laboratory.

a suitable test for measuring the degree to which a road material possesses this property.

"With homogeneous, structureless, brittle materials, resistance to impact may be due to a relatively low modulus of elasticity combined with high elastic limit. Provided a blow is delivered by a flat striking head with small local damage, on such a material toughness will be almost wholly due to elasticity. In this case there will be a critical energy of blow below which the specimen under test will not be broken by an indefinite number of blows, and in excess of which it will be broken by a single blow. The toughness of a road material in this instance will vary directly as the square of the elastic limit, which equals the ultimate strength, and inversely as the modulus of elasticity. In testing such materials under impact it would be necessary to apply a number of blows of successively increasing energy, and note that blow which causes failure. A test involving this principle will be described further on in detail.

"*Cementing or Binding Power.* The binding power, or as it has now come to be called, the cementing value of a road material, is the property possessed by rock dust or other finely divided material found in nature to act as a cement on the coarser fragments composing crushed stone or gravel roads. This property varies enormously not only with different kinds of rocks, but also with those which are practically identical in classification and chemical composition. The absence of cementing power is so pronounced in some varieties of rock that they can never be made to compact with the road roller or under traffic. As the binder surface of a macadam or gravel road is most exposed to the action of wind and rain, as well as the wear and tear of traffic, it can be seen that the presence of this property is most essential to good results. Further than this, the hardness and toughness of the binder surface, more than of the rock itself, constitutes the hardness and toughness of the road, for if a load be sufficient to destroy the bond of cementation of the upper surface of a road, the stones below are soon loosened and forced out of place. The impervious shell obtained by the use of a rock of high cementing value gives the greatest protection to the foundation of a road. Moreover, it is a matter of common observation that a good surface which binds well

is less dusty and less muddy, while the advantage from the standpoint of economy is very great, as it is only the loose, unbound material which is ordinarily carried away by wind and water.

"In view, therefore, of the importance of this property, it has been made the subject of especial study in this laboratory. It was most important to know the cause of the cementing value in order to determine what could be done to improve the conditions of service.

"It appears that the cementing value depends upon a certain hydrated colloid condition of the particles or some proportion of the particles. All rock powders that cement well are hydrated, i. e., contain water of combination, although it does not follow that all hydrated rock powders will cement. It seems that only a certain kind of water of combination is concerned with and measures the cementing value. This property is undoubtedly related to that of plasticity in clays, and, in a few words, is due to amorphous, inorganic particles which by reason of their characteristic porous structure are able to absorb and hold water, thereupon assuming a plastic and coherent condition. Heating above a certain temperature destroys this structure and the powder no longer possesses the slightest cementing value."

Methods and Tests of the U. S. Road Material Laboratory.

The primary object of this laboratory is to make standard tests on road materials, free of charge, for citizens of the United States. In addition to this allied problems may be presented for study, such as the suitability of clays for the manufacture of paving brick, drain tiles, cements, etc., the testing of cements and concretes for road foundations, drains, gutters and highway bridges. It is the intention of the Department to aid, as far as possible, in the solution of all the problems of road building, but more particularly those relating to rural highways. Up to January 1, 1906, tests of 940 samples from all parts of the United States had been made in this laboratory. The results of these tests are given in the following table:

Maximum, Minimum and Average Results on Rock Samples Corrected to January 1, 1906.

No. of Samples.	Name.	Per Cent. of Wear.			French Coefficient of Wear.			Hardness.			Toughness.			Weight Per Cubic Foot.			Water Absorbed.			Specific Gravity.			Cementing Value. Dry Grinding.			Cementing Value. Wet Grinding.		
		Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max. Lbs.	Min. Lbs.	Av. Lbs.	Max. Lbs.	Min. Lbs.	Av. Lbs.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
9	Amphibolite	4.7	1.0	2.9	41.7	8.5	20.9	18.1	17.0	18.0	18	9	10	193.4	171.5	195.7	0.62	0.04	0.30	3.1	2.7	3.0	36	2	9	73	11	29
4	Andesite	6.4	2.6	3.9	15.3	6.3	11.4	14.6	14.6	14.6	17	17	17	168.4	152.8	159.0	2.83	0.53	1.85	2.7	2.5	2.6	337	8	120	...	..	...
34	Basalt (Trap)	14.7	1.3	3.8	30.4	2.7	15.8	17.8	- 6.8	13.0	39	6	22	190.2	152.8	171.5	6.32	0.64	1.39	3.1	2.5	2.8	500+	1	60	500+	5	141
29	Chert	27.9	2.7	10.8	14.6	1.4	5.5	18.8	18.3	18.6	21	7	15	184.4	124.7	156.1	11.10	0.46	2.28	3.0	2.0	2.5	36	1	11	106	5	27
4	Conglomerate	12.7	3.5	6.6	11.6	3.2	7.6	...	...	...	..	..	..	159.0	155.9	157.4	3.71	2.50	3.11	2.6	2.5	2.6	327	12	170	...	..	...
99	Diabase (Trap)	6.3	1.2	2.4	34.5	6.4	18.6	18.5	5.3	15.2	54	4	26	199.6	162.2	186.0	2.73	0.04	0.32	3.2	2.6	3.0	301	2	31	500+	7	146
21	Diorite (Trap)	4.0	1.6	2.7	21.3	10.0	14.9	16.8	13.8	15.0	24	15	21	196.5	168.4	181.3	1.03	0.06	0.36	3.2	2.7	2.9	137	1	18	148	9	48
45	Dolomite	18.6	2.4	5.6	16.9	2.2	8.0	15.8	4.3	8.2	27	4	10	177.8	159.0	170.5	4.77	0.08	1.29	9.6	2.5	2.9	161	2	21	179	13	45
5	Eclogite	2.9	1.8	2.4	22.7	13.8	17.6	15.3	15.3	15.3	31	31	31	227.7	187.1	202.7	0.27	0.10	0.15	3.7	3.0	3.3	20	1	8	130	15	48
11	Felsite	3.4	1.9	2.6	21.3	11.9	15.2	...	...	...	..	..	..	174.6	159.0	165.3	3.13	0.02	0.84	2.8	2.5	2.7	101	2	34	...	..	...
89	Field stone	10.3	2.1	4.1	19.2	4.6	10.9	...	...	...	..	..	..	...	...	...	...	...	...	...	...	...	46	5	17	16	16	16
15	Gabbro	5.4	1.3	2.7	30.8	7.5	16.1	17.5	12.9	15.5	22	10	16	193.4	171.5	186.9	0.23	0.04	0.25	3.1	2.8	3.0	431	1	20	491	7	75
41	Gneiss	8.1	1.7	3.7	23.0	4.9	12.2	17.8	10.5	15.1	20	5	13	187.1	162.2	171.1	0.98	0.10	0.29	3.0	2.6	2.8	21	0	5	61	1	32
72	Granite	14.8	1.1	3.7	37.0	2.7	12.6	18.3	12.5	15.6	29	4	12	187.1	155.9	165.2	1.96	0.04	0.32	3.0	2.5	2.7	77	1	7	88	3	21
67	Gravel	...	...	...	...	...	...	...	...	...	..	..	..	...	...	...	...	...	...	...	...	...	500+	1	74	500+	13	81
192	Limestone	34.2	2.1	5.7	19.0	1.2	8.7	16.0	- 70.6	3.4	20	3	11	193.4	131.0	165.7	13.22	0.03	1.39	3.1	2.1	2.7	231	2	32	500+	14	59
4	Marble	14.0	3.8	6.9	10.5	2.9	7.6	11.5	- 4.8	3.4	9	6	8	177.8	168.4	171.5	1.04	0.16	0.52	2.8	2.7	2.9	15	5	10	77	71	74
6	Marl	...	...	...	...	...	...	...	...	...	..	..	..	...	...	...	...	...	...	...	...	...	500+	55	323	...	..	...
19	Mixed stone	10.3	2.1	3.9	19.1	3.9	12.1	...	...	...	..	..	..	174.6	174.6	174.6	0.22	0.22	0.22	2.8	2.8	2.8	29	12	19	39	16	25
3	Peridotite (Trap)	4.3	3.6	4.0	11.1	9.3	9.9	11.6	11.6	11.6	12	12	12	221.4	199.6	212.1	0.33	0.27	0.30	3.6	3.3	3.4	14	3	9	30	25	28
34	Quartzite	4.7	1.6	3.0	24.5	8.5	14.4	18.2	12.6	16.7	30	10	20	190.2	159.0	170.0	1.30	0.06	0.31	3.1	2.6	2.7	9	0	3	42	0	18
13	Rhyolite	9.7	1.7	4.3	23.0	4.1	13.1	17.8	7.1	14.6	33	6	20	177.8	134.1	162.7	5.87	0.03	1.54	2.9	2.2	2.6	500+	0	47	500+	5	90
56	Sandstone	32.8	1.6	8.5	25.7	1.2	10.8	17.9	-130.0	1.3	47	3	24	193.4	123.4	161.8	11.60	0.02	2.15	3.1	2.0	2.5	323	1	38	500+	12	95
40	Schist	7.1	1.8	4.1	22.6	4.9	11.6	17.0	12.5	15.3	34	6	24	199.6	165.3	184.5	1.19	0.06	0.37	3.2	2.7	3.0	127	1	19	232	11	55
8	Shale	16.2	4.7	10.5	8.6	2.5	5.6	7.0	7.0	7.0	3	3	3	171.5	155.9	165.3	4.84	0.87	2.39	2.7	2.5	2.7	500+	9	276	...	..	...
5	Slag	10.6	7.6	8.8	5.2	3.8	4.6	...	...	...	..	..	..	171.5	140.3	159.0	4.10	0.04	1.56	2.7	2.3	2.6	137	2	42	262	31	123
9	Slate	6.9	2.6	5.0	15.2	5.8	6.9	15.8	- 6.8	2.6	22	5	14	177.8	168.4	174.6	0.68	0.15	0.43	2.8	2.7	2.8	202	7	81	...	..	...
6	Syenite	3.2	1.9	2.6	21.0	12.6	16.1	16.5	16.5	16.5	10	10	10	187.1	168.4	174.6	0.40	0.10	0.22	3.0	2.7	2.8	11	2	6	27	20	24

Test for Hardness.—The test for hardness is made with the Dorry machine. The specimens to be tested are sawed into rectangular prisms 8 cm. high with a base 4 cm. by 6 cm. These specimens are placed, two at a time, so that they rest on the upper surface of a circular grinding disk of cast iron, which is rotated in a horizontal plane by a crank. They are held in clamps so arranged that the bases of the specimens rest on alternate sides of the grinding disk 26 cm. from the center. The specimens are weighted so that they press against the grinding disk with a pressure of 250 grams per square centimeter. Sand of a standard quality and size, obtained by crushing quartzite rock and screening it, is fed onto the disk from a funnel. The quantity of sand used in each test is 4 liters. The disk is rotated at the rate of 2,000 revolutions per hour for two hours.

After 2,000 revolutions the specimens are reversed to ascertain if there is any difference in wear between the two ends and to make the result approach more nearly a general average of the samples. The diminution in the height of the specimen is measured and its loss in weight determined after each 1,000 turns of the grinding disk. No coefficient of wear has been established for this test, but the loss in height undergone by each specimen after 4,000 revolutions of the disk is taken as the result of the test and serves for comparison. Tests are always made on at least three specimens of each sample, and the final result is taken from their average.

In a recent letter Mr. Page has also stated that "the minus sign appearing before a hardness result means that the sample is very soft as the range of possible values given below will indicate. The range is from perfect hardness (20) down past zero into minus values. The result is obtained as follows: Hardness equals 20 minus the wear from the end of the specimen as held in the hardness machine measured in millimeters.

From this it is apparent that if the loss of length from wear is more than 20 millimeters, the result has a minus sign. If the loss is just 20 millimeters, the result will be zero.

The values may range from $<$ 20 down to —10 or —15, though specimens are rarely tested for road purposes which are soft enough to give a result as low as zero.

Test for Toughness.—This test is made on 25 mm. x 25 mm. (0.98 inch) rock cylinders with an impact machine especially designed for the purpose. A plunger with the lower and bearing surface of spherical shape, having a radius of 1 cm. (0.4 inch) is used. It can be seen that the blow as delivered through a spherical end plunger approximates as nearly as practicable the blows of traffic. Besides this it has the further advantage of not requiring great exactness in getting the two bearing surfaces of the test piece parallel, as the entire load is applied at one point on the upper surface. The test piece is adjusted so that the center of its upper surface is tangent to the spherical end of the plunger, and the plunger is pressed firmly upon the test piece by two spiral springs which surround the plunger guide rods. The test piece is held to the base of the machine by a device which prevents its rebounding when a blow is struck by the hammer. The hammer weighs two kg. and is raised by a sprocket chain and released automatically by a concentric electro-magnet. The test consists of a 1 cm. fall of the hammer for the first blow, and an increased fall of 1 cm. for each succeeding blow until failure of the test piece occurs. The number of blows required to destroy the test piece is used to represent the toughness.

The cylindrical test pieces employed are made with a core saw designed for the purpose. It consists of a steel tube supported by journals in a vertical position and held in a cast iron frame. A link motion lever rests on the upper end of the tube on a ball bearing. A spiral spring is attached to the free end of the lever by which the downward pressure of the tube can be adjusted. Water is fed in the top of the tube by a small rubber hose, and at the center is a pulley wheel by which the tube is revolved at about 800 revolutions per minute. The bottom or cutting end of the tube is set with bort by a specially designed method. This saw cuts very rapidly and the waste is very much less than in cube cutting, in addition to which the cylindrical test piece is better adapted for this test.

Abrasion Test.—This test to determine the per cent. of wear and the French coefficient of wear is made on what is known as the Deval machine, which was the first one designed especially for testing road materials. It consists of eight iron cylinders fastened

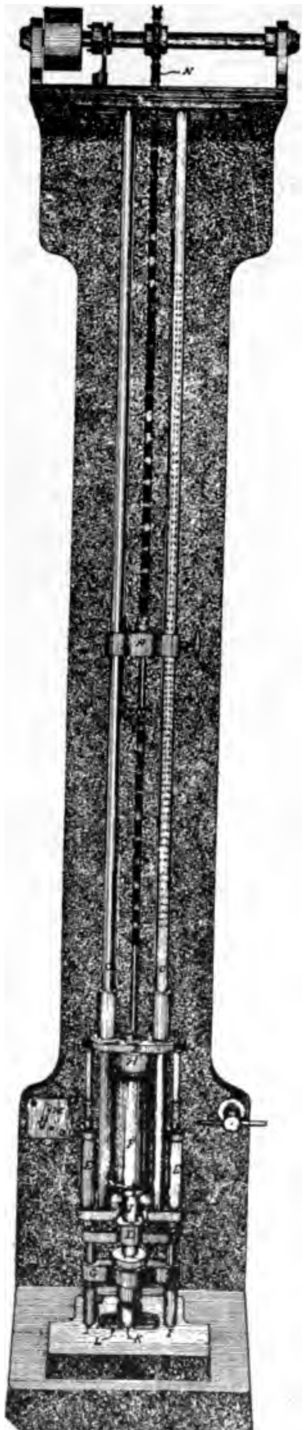


Fig. 6. Impact Machine for determining toughness,

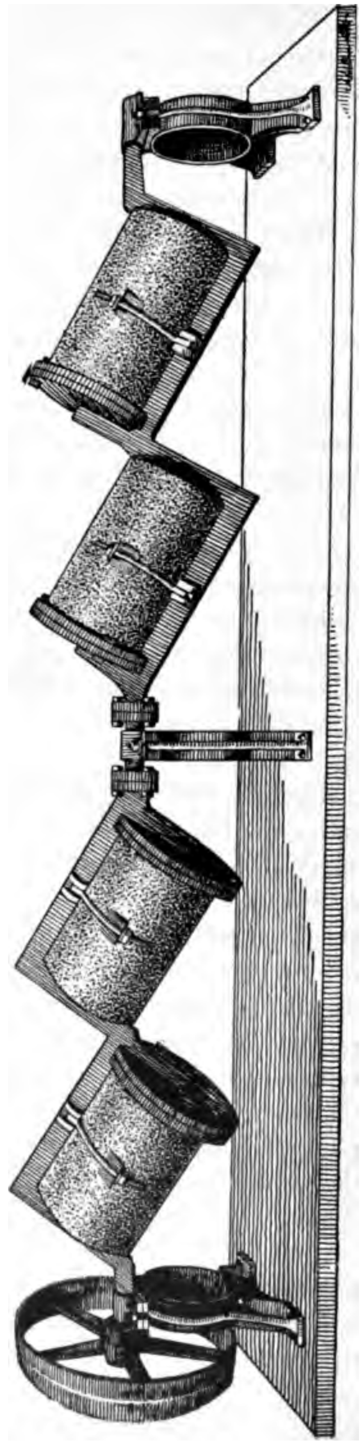


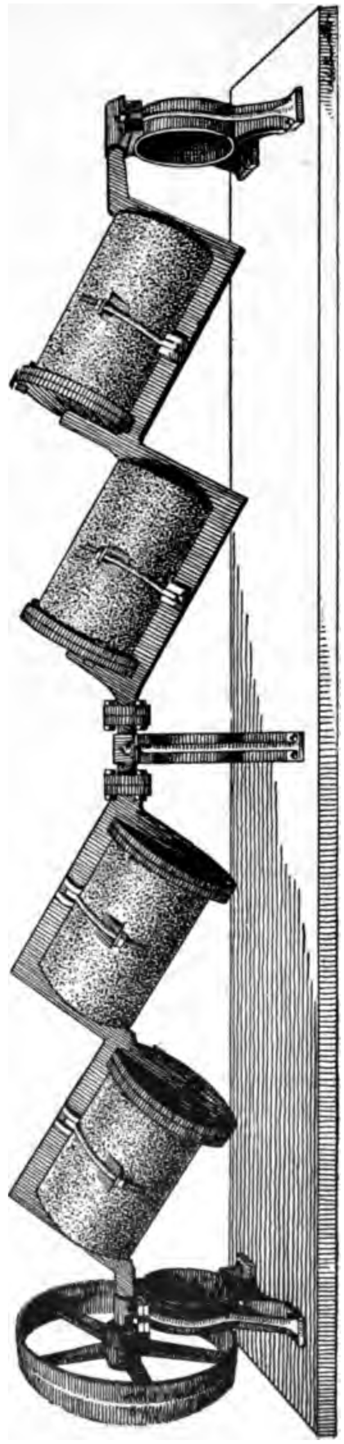
Fig. 7. Abrasion Machine.

to a shaft so that the axis of each cylinder is at an angle of 30 degrees with the axis of rotation. Each cylinder is 20 cm. in diameter and 34 cm. in depth, closed at one end and with a tightly fitting iron cover for the other. The eight cylinders are mounted four by four on two parallel shafts geared to rotate with the same rapidity. This arrangement renders it possible to make eight tests at the same time. The method of operation is as follows:

"The sample to be tested is first broken in pieces that will pass in all positions through a 6 cm. (2.4 inch) ring, but not through a 3 cm. (1.2 inch) ring. The stones are then cleansed, dried in a hot-air bath at 100°C., and cooled in a desiccator. Five kilograms are weighed and placed in one of the cylinders, the cover bolted on and the machine rotated at the rate of 2,000 revolutions per hour for five hours. The fragments of stone are thrown from one end of the cylinder to the other twice in each revolution, and thus grind and pound against one another and the ends of the cylinder. When the 10,000 revolutions of the machine are completed, the contents of the cylinder are placed on a sieve of 0.16 cm. (1-16 inch) mesh, and the material which passes through is again sifted through a sieve of 0.025 cm. (0.01 inch) mesh. Both sieves and the fragments of rock remaining on them are held under running water until all the adhering dust is washed off. After the fragments have been dried in a hot-air bath at 100°C. and cooled in a desiccator they are weighed and their weight subtracted from the original 5 kg. (11 pounds). The difference obtained is the weight of detritus under 0.16 cm. (1-16 inch) worn off in the test. By dividing this weight by the original weight of 5 kg. (11 pounds) the *"per cent. of wear"* reported is obtained.

In France, where the Deval machine has been in use since 1878, "a standard rock of superior wearing quality was at first always placed in one of the cylinders as a standard of comparison, and the proportion of the weights of the dust under 0.16 cm. from the standard rock and from the rock to be tested was assumed to give their relative resistance to abrasion. It was found, however, that only the best varieties of rock gave less than 100 grams of powder under 0.16 cm., i. e., 20 grams per kilogram of rock, or 2 per cent. of their weight. The number 20 was, therefore, adopted as a

Fig. 6. Impact Machine for determining toughness.



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standard of excellence, and the "coefficient of wear" for any rock tested may be obtained by the following formula:

$$\text{Coefficient of wear} = 20 \times \frac{20}{W} = \frac{400}{W}$$

in which "W" is the weight in grams of the detritus under 0.16 cm. in size obtained per kilogram of rock used. This is known as the *"French coefficient of wear,"* and the result is reported as such in the results of tests given out by the U. S. Road Laboratory.

"Cementation Test.—The binding or cementing power of rock dust is such an important element in road building that much time has been spent in the endeavor to devise a suitable test for determining the degree to which the various rocks and gravels possess this property. Many tests have been tried, but as yet only an impact test, carried on in a uniform manner as described below, has given satisfactory results.

"One kilogram of the rock to be tested is broken sufficiently small to pass a 6 mm., but not a 1 mm. mesh screen. It is then placed in a ball mill and is ground for two hours and a half. This ball mill contains two chilled iron balls which weigh 25 pounds each, and is revolved at the rate of 2,000 revolutions per hour. It was found by experiment that grinding rock thus prepared for two hours and a half was sufficient to reduce it to a powder that would pass through a 0.25 mm. mesh. The dust thus obtained is mixed with water to about the consistency of a stiff dough, and is kept in a closed jar for twenty-four hours. About 25 grams of this dough is placed in a cylindrical metal die, 25 mm. in diameter. A closely fitting plug, supported by guide rods, is inserted over the material, which is then subjected to a pressure of 100 kg. per square centimeter. It is most important that these briquettes should be compressed in a uniform manner, and for this a special machine has been designed. The die is placed on an iron platform supported by a piston rod, which is connected directly with a hydraulic piston below. Water from a tank is admitted to the hydraulic cylinder through a small orifice in the pipe. As the piston rises the platform and die are carried up with it, the plug of the latter coming in contact with a yoke attached to a properly weighted lever arm. When the lever arm is raised one-eighth of an inch it closes an electric circuit which trips a right-angle cock, shutting off the water

and opening the exhaust. One minute is required to compress a briquette, and the maximum load is applied only for an instant. By this device practically uniform conditions are obtained.

The height of the briquette is measured, and if it is not exactly 25 mm. the requisite amount of material is added or subtracted to make the next briquette the required height. Five briquettes are made from each test sample and allowed to dry 12 hours in air and 12 hours in a steam bath. After cooling in a desiccator they are tested by impact in a machine especially designed for the purpose. It consists of a 1 kg. (2.2 pounds hammer (H), which is guided by two vertical rods (D). The hammer (H), which ends in a small cone at the top (L), is caught on the lower side of the cone by two spring bolts (S) and is lifted by a crosshead (I) which is joined to a crank shaft above. A vertical rod (P), which is directly over the hammer cone, can be adjusted by thumbscrews to give a drop to the hammer varying from a fraction of a millimeter to 10 cm. This rod has a hollow cone at its lower end into which the cone of the hammer head is thrust when the hammer is lifted by the crosshead (I). When the cone of the hammer head is brought into the cone of the adjusting rod the hammer is exactly centered and brought free of the guide rods (D). As the crosshead (I) continues to rise, the bolts supporting the hammer, which are tapered at an angle of about 45°, are thrust open by the sloping head of the adjusting cone rod (P) releasing the hammer, which falls on a flat-end plunger (B) of 1 kg. weight, which is pressed upon the briquette (O) by two light spiral springs surrounding the guide rods (F). This plunger (B) is bolted to a crosshead (G). A small lever (J) holding a brass pencil (K) at its free end, is connected with the side of the crosshead, by a link motion arranged so that it gives a vertical movement to the pencil five times as great as the movement of the crosshead. The pencil is pressed against a drum (A), and its movement is recorded on a slip of silicated paper fastened thereon. The drum is moved automatically through a small angle at each stroke of the hammer; in this way a record is obtained of the movement of the crosshead during and after each blow of the hammer. To the crosshead (G) is fastened a steel rod (R) which passes up through the crosshead (I) and through a piece of metal securely attached to the cone rod (P). At this junc-

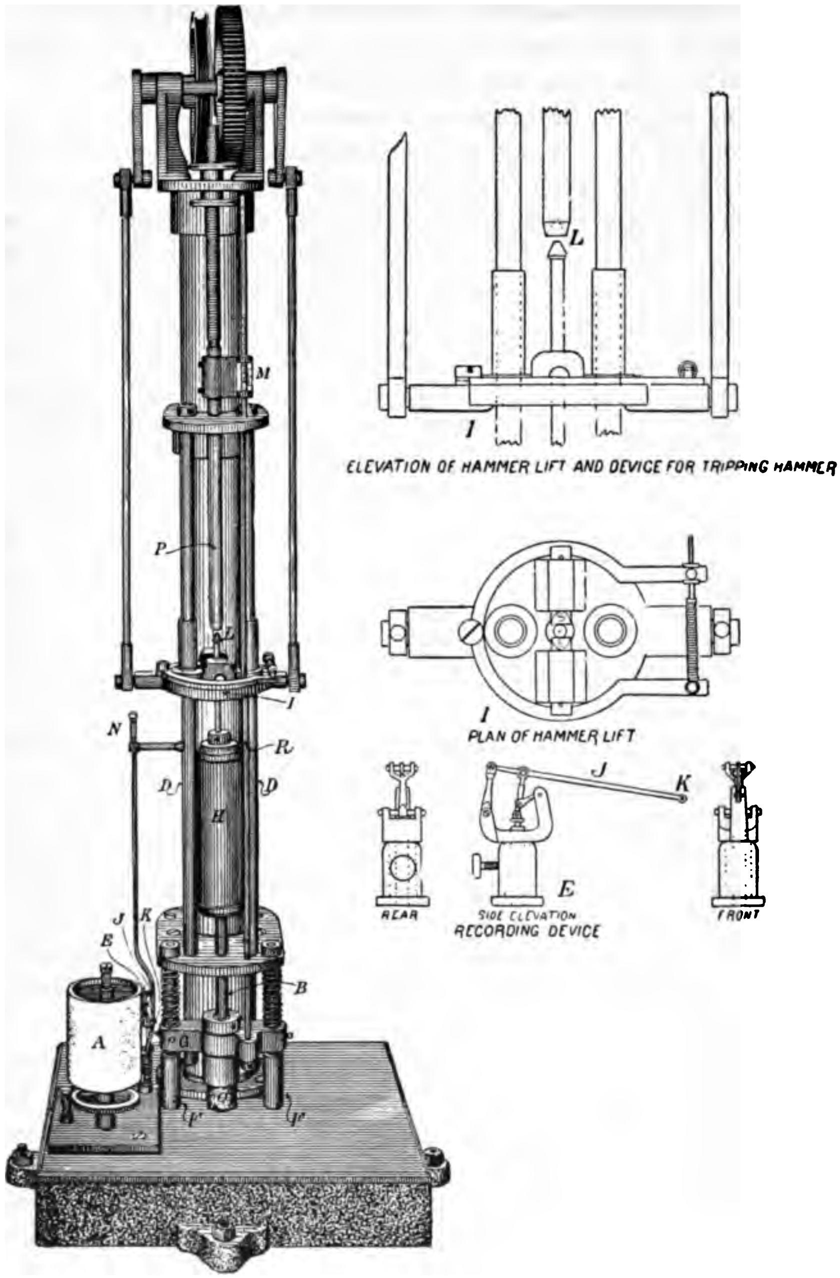

Fig. 8. Impact machine to determine cementing value of rock.

tion a vernier scale is graduated, by means of which the height of blow of the hammer can be accurately set to 0.1 mm., and by lowering the cone rod until it rests on the hammer cone (L) the height of the briquette can also be measured to 0.1 mm.

The standard fall of the hammer for a test is 1 cm. (0.39 inch) and this blow is repeated until the bond of cementation of the material is destroyed. The blow producing failure is easily ascertained, for when the hammer falls on the plunger, if the material beneath it can withstand the blow it recovers; if not, the plunger stays at the point to which it is driven, and in either case the behavior of the test piece is recorded on the drum. The automatic record thus obtained from each briquette is filed for future reference. The number of blows required to destroy the bond of cementation or resilience, as described above, is noted and the average obtained upon five briquettes is given as the *dry cementing value.*

The wet grinding test for cementing value is a comparatively late development and is carried out as follows:

A quantity of the dust as it comes from the ball mills in the dry test is mixed with a sufficient amount of water to make it into a pasty condition, not too wet; is then put back in the mill and ground for a length of time equal to that in which the original dry grinding was done. The briquettes are then moulded and tested in exactly the same manner as in the dry test, the result being the *wet cementing value.*

Absorption Test.—The method used for determining the absorptiveness of rock is not intended to give the porosity but merely the number of pounds of water that is absorbed by a cubic foot of rock in ninety-six hours. A smoothly worn stone, between 20 and 60 grams in weight, which has been through the abrasion test is used. After being weighed in air, it is immersed in water and immediately reweighed in water. After ninety-six hours of immersion it is again weighed in water. The absorptiveness of the rock is expressed by the following formula:

Number of pounds of water absorbed by a cubic foot of rock=

$$\frac{C-B}{A-B}\times 62.5$$

in which A is equal to the weight in air, B the weight in water immediately after immersion, C the weight in water after absorp-

tion for ninety-six hours, and 62.5 the weight of a cubic foot of water. From these weights the specific gravity and the weight per cubic foot of the rock are also determined.

The Application of Laboratory Results to Practice.

The proper interpretation and application of the results obtained in the laboratory are quite as important as the general accuracy and appropriateness of the tests themselves. It is probable that many engineers and others interested in the subject of road building who have found time to examine the question only superficially have misunderstood the bearing and value of road-material testing. In all cases the results obtained in testing materials of construction are of relative rather than absolute value. Even quite a large variation in the results yielded by different test pieces of the same sample should not condemn the practical value of the figures if they are properly applied and interpreted. The necessary qualities of road materials have to be considered from the double standpoint of furnishing a strong, unyielding, well-drained road foundation and a hard, coherent binder surface. In road building the attempt should be made to get a perfectly smooth surface, neither too hard, too slippery, nor too noisy, and as free as possible from mud and dust, these results to be attained and maintained as cheaply as possible. Such results, however, can be achieved only by selecting the material and methods of construction best suited to the conditions.

Given a number of materials for laboratory examination, it is not pretended that an actual practical grade of excellence can be established. On the other hand, if more than one material is available, it is quite possible for the laboratory to point out which one would yield the best results both as to immediate excellence and length of life under known conditions of climate and traffic. Undoubtedly in many cases large sums of money have been wasted in building roads from unsuitable material, which might have been saved by referring the materials to the laboratory. If, for instance, it is desired to know whether an available rock will be useful as a top dressing to form the binder surface, no better method of obtaining preliminary information on the subject is known than to test the cementing value. Undoubtedly some rocks will yield

powder from successive test pieces which shows very wide variations in this value under the conditions of the test, but there is at present no difficulty in distinguishing between good and bad material.

Those who are familiar with the problems of rural road building know the great difficulty of selecting among the available materials for a particular road the one which will give the best results for the least cost of construction and maintenance. There are, undoubtedly, practical road builders whose judgment on the road-making quality of a rock is excellent, but experience with materials of construction in general has proved that it is wise and economical to test the physical properties of materials before entering on the expenditure of large sums of money. Bridge building would not have become the high art that it has had not the careful and systematic testing of materials put into the hands of the engineer preliminary data on which to base his calculations and estimates.

Standard of Comparison.

The quality of a rock for macadam road building can not be accurately judged by the physical tests alone. There must also be taken into consideration the volume and character of traffic of the road on which the material is to be used, as well as the topography and the climatic conditions. These necessarily vary to a great extent in the different parts of the State. For these reasons there is no well defined or fixed standard which can be arbitrarily used for comparing the results of the tests made on the rock samples submitted from Indiana. Since, however, those rocks were all limestones, it has been thought best to take the *average results* of tests made on the 192 samples of limestone tested in the U. S. Laboratory prior to January 1st, 1906, as such a standard. This average is as follows:

Average of Tests of 192 Samples of Limestone made at the U. S. Road Laboratory. Taken as a Standard of Comparison for Tests on Indiana Limestone.

Specific gravity..............	2.7	French coefficient of wear.	8.7
Weight per cu. ft..........(lbs.)	165.7	Hardness.................	3.4
Water absorbed per cu. ft..(lbs.)	1.39	Toughness................	11
Per cent. of wear..............	5.7	Cementing value—Dry....	32
		Wet....	59

Under the results of each test of limestone as given on subsequent pages are inserted in quotes certain remarks by Mr. Page, Director of the Laboratory. These usually refer to the fitness of the material for use on country roads and highways.

SECTION IV.

(a) ADVANTAGES OF GOOD ROADS. (b) CONSTRUCTION OF IMPROVED ROADS.

BY W. S. BLATCHLEY.

As far back as 1776, Adam Smith, in his "Wealth of Nations," wrote as follows: "Good roads, canals and navigable rivers, by diminishing the expense of carriage, put the remote parts of the country more nearly upon a level with those in the neighborhood of the town. They are upon that account the greatest of all improvements. They encourage the cultivation of the remote, which must always be the most expensive circle of the country. They are advantageous to the town by breaking down the monopoly of the country in its neighborhood. They are advantageous even to that part of the country. Though they introduce some rival commodities into the old market, they open many new markets to its produce."

The truth of the celebrated Scottish economist's statement has since been exemplified in many nations and in many states. The century and a quarter which have elapsed since it was written has been sufficient to prove that those localities where good roads have been built are becoming richer, more prosperous and more thickly settled, while those which do not possess these advantages in transportation are either at a standstill or are becoming poorer and more sparsely settled.

Especially is this true of Indiana, where the good roads question is, at present, one of the most vital with which the farming community has to deal. Many of the better counties of the State long ago realized the importance of this question, and, where the road material was conveniently located, constructed gravel or macadam roads radiating in all directions from their county towns. In other counties possessing a plentiful supply of road material the importance of the question has not yet been fully realized, and for six months of the year the farmers are practically isolated from

market, or, if they manage to reach it once a week, can only haul thereto a fraction of a load. Such counties are readily recognized as far below the average in wealth, prosperity and the public spirit of their citizens.

The difference between good and bad roads is often equivalent to the difference between profit and loss. Good roads have a money value to farmers as well as a political and social value, and looking at them only from the "almighty dollar" side, they are found to pay handsome dividends each year. This has been well proven by Prof. W. C. Latta, of Purdue University, who, a few years ago, collected from the farmers of Indiana some important information on the subject of the increased value of land in the State, due to good roads. He sent out letters and received reports from many farmers, some of whom live on good roads once bad and others on roads still bad. From these reports he computed statistics showing that the difference between good and bad roads amounts to 78 cents an acre annually on the farms. Apply this amount to the entire State—36,350 square miles, or 23,264,000 acres—and we have the sum of $18,145,920. Of this amount fully two-thirds is wasted every year in the State in the loss of time and in the loss of opportunity in securing the best market for the produce of the farm. From the answers received, Prof. Latta also drew the following conclusions:

"(1) The average estimated increase in the selling price of land due to existing improved highways is $6.48 per acre. The estimates from which this average is made refer in most cases to lands near the improved roads; but in a few instances they apply to all the lands of the county. The average increase, therefore, of $6.48 per acre is lower than was intended for the lands near the improved roads.

(2) The estimated average increase per acre that would result from improving all the public roads is $9.00.

(3) The estimated average cost of converting the common public roads into improved highways is $1,146 per mile."*

That the above estimate of Prof. Latta with regard to the increased value of the land is not excessive may be shown from other States. The farmers of Canandaigua County, New York, who

*Circ. 23, Office of Road Inquiry, U. S. Dept. Agr.

have themselves built a number of miles of hard roads at a cost of $1.50 per acre of the adjoining farms, find that their land has increased in value $20 to $30 per acre. Again, from New Jersey, where one of the Road Commissioners of the State has collected many opinions from the farmers living in the neighborhood of roads lately improved, all of whom state that they would not go back to the old roads under any conditions. One of them, voicing the popular sentiment, says: "I would not sell my farm and accept another worth $7,000 as a gift, and be obliged to live on it two miles from a macadam road. No farmer in the neighborhood would buy a farm not located on such a road. Now that they have experienced improved roads, all want them."* Similar sentiments come from Maryland, Georgia and a number of other States.

A few years ago the Office of Road Inquiry at Washington, D. C., sent out 10,000 letters to intelligent and reliable farmers throughout the United States, asking certain information relative to the traffic upon country roads. From the replies statistics were compiled showing the average length of haul, in miles, from farms to market or shipping points; the average weight of load hauled; and the average cost per ton per mile; and from these data was deduced the average cost per ton for the whole length of haul.

"These returns were arranged in groups of States, and the result showed that the average length of haul in the Eastern States is 5.9 miles; in the Northern States, 6.9 miles; in the Middle States, 8.8 miles; in the cotton States, 12.6 miles; in the prairie States, 8.8 miles; in the Pacific Coast and mountain States, 23.3 miles; and in the whole United States, 12.1 miles.

The average weight of load for two horses in the Eastern States is 2,216 pounds; cotton States, 1,397 pounds; prairie States, 2,409 pounds; Pacific Coast and mountain States, 2,197 pounds; and the whole United States, 2,002 pounds.

The average cost per ton of 2,000 pounds per mile in the Eastern States is 32 cents; Northern States, 27 cents; Middle-Southern States, 31 cents; cotton States, 25 cents; prairie States, 22 cents; Pacific Coast and mountain States, 22 cents; and the whole United States, 25 cents.

The average total cost per ton for the whole length of haul is as

*Bull. 9, Office Road Inquiry, U. S. Dept. Agr.

follows: Eastern States, $1.89; Northern States, $1.86; Middle-Southern States, $2.72; cotton States, $3.05; prairie States, $1.94; Pacific Coast and mountain States, $5.12; and the whole United States, $3.02."*

From inquiry I learn that in this investigation Indiana was classed as a prairie State; the average results of the points mentioned being:

Average length of haul, 4.6 miles.
Average load for two horses, 2,272 pounds.
Average cost per ton per mile, 28 cents.
Average total cost per ton for whole length of haul, $1.28.

From the data thus gathered, taken in connection with that supplied by the Division of Statistics relative to farm products, the Director of the Office of Public Roads estimated approximately the total amount in tons and total cost of the entire movement of farm products, including forest products, over the country roads of the United States to be as follows:

Total farm products hauled on public roads, 313,349,227 tons per annum.

Average cost of haulage, as above stated, $3.02 per ton.

Total annual cost of haulage of farm products on public roads, $946,414,665.

The immensity of this charge will be best realized by comparing it with the value of all farm products, including forest products, in the United States for the year 1899, which, according to census returns, was $4,717,069,973, thus showing the cost of haulage to be 20+ per cent. of the total value of all products of the farm.

A lesson on the need and value of road improvement might be learned from the great railway managers of the nation, if the farmers only would do so. Those railway managers are spending millions upon millions of dollars, not in building new railways, but in improving old ones. Take for example the Cincinnati Division of the Big Four Railway between Indianapolis and Cincinnati, where two millions of dollars have been spent in the last three years in eliminating curves, reducing grades, building steel bridges and concrete arches, making more solid embankments and

*Circ. 19, Office Road Inquiry, U. S. Dept. Agr.

laying heavier rails. Why was this done? Not simply that the traveler may ride with a little more comfort than heretofore, but mainly that a given amount of power shall be able to haul more tons, and that the motive power and rolling stock shall be subject to less strain and shock than had to be borne when the road was in the old condition. If a single railway management finds that it pays to spend millions in making the best road that they can build, why will not the same reasoning hold good for the people in connection with the country highways? There is no essential difference in principle between the improvement of a railroad and the improvement of a wagon-road, and the wisdom of the brightest minds in the railway world asserts that the *best* railway which can be constructed is the most economical.

The increase in cost of haulage actually done is by no means the only loss by bad roads. The loss of perishable products for want of access to market; the failure to reach market when prices are good; and the failure to cultivate products which would be marketable if markets were always accessible, add many millions to the actual tax of bad roads. Moreover, the enforced idleness of millions of men and draft animals during large portions of the year is a loss not always taken into account in estimating the cost of work actually done.

All farmers recognize that much of the work of the farm is concentrated in certain periods, and that at other times there is comparatively little work to be done. Now it is just at these times when the farmer has leisure that the roads are in their very worst condition and he is obliged to remain on the farm. On the other hand, in the busiest season he must often leave important duties to haul products which might have been hauled in winter, had the roads only been in fit condition. Much of the hauling of fertilizers and wood, and most of that of the grain to market could thus be done with ease in the winter. Moreover, the hauling which must necessarily be done in summer could be performed in shorter time and with less interruption to other work.

This question of winter hauling came up to the writer very forcibly a year or two ago while writing a paper on the petroleum industry in Indiana. In preparing a map for that paper it was found that many farms in the very center of productive territory

had not been drilled because they were on mud roads and distant from railway stations. The iron drive pipe, casing and tubing and the derrick timbers necessary for drilling in and pumping a productive well are very heavy, and it is almost impossible to haul them over many of the roads in the oil field between the first of November and the first of April. The operator, therefore, develops first those leases on pike roads or close to railway stations, leaving those on mud roads to the very last. The farmers living in the oil belt who are receiving or might receive large sums in royalty for their oil should, therefore, see to it that their farms are accessible at all times. A successful oil operator is usually a busy man, who does not wish to lose five-twelfths of his time on account of bad roads; hence he leaves the territory with mud roads and operates that which he can reach 365 days in the year.

During the past decade our vehicles for rapid country travel have become more numerous and of an entirely different style from what they were twenty years ago. Almost every farmer now owns his own buggy and carriage. The bicycle by countless thousands has come to stay, and the automobile will soon be more common on the improved roads of the State than the two-horse surrey was a dozen years ago. The owners of all these forms of vehicles are demanding, and will continue to demand, better roads, and the legislator must soon learn that the question is one of the most important which he has to face.

Another phase of the good roads question came into existence with the twentieth century. Five years ago the rural mail carrier was an almost unknown factor in our State. Now he travels in every county, carrying his messages of joy or sorrow to the farmer's door each day. The daily paper, with its market reports and news of the world, is, or can be, put regularly into the farmer's hands within a dozen hours of its issue, even though he lives a score of miles from a railway. Time is the most valuable possession given to man on earth, provided he has the ability and cares to use it to his advantage. The time saved in going to town for the mail or for some necessity which the mail carrier can bring is the most important advantage of the rural free delivery system. But this system will not, can not and should not be made a permanent factor in the country unless the farmers see to it that the roads are

kept in such a condition that the route can be covered in the time allotted. The United States Government, through its Postoffice Department, demands that the farmers do this much, and the demand is just. Those farmers of the State who have had the foresight and good judgment to improve the roads in their vicinity are, for the most part, contented and prosperous. Their products are easily gotten to market when the price is at its best, and the wolf never rests on his haunches before their doors.

On the other hand, those living in the bad road districts endure, for more than a third of their time, an enforced idleness, which makes them ever poorer and causes them to cry out against their lot in life, rather than against their own short-sightedness on the road question. Indiana is rich in gravel, rich in stone for macadam roads, rich in clay suitable for vitrified brick. There is no reason, therefore, why every public road of any importance in the State should not be improved, so that it may be traveled with ease any day in the year.

(b) Construction of Improved Roads.

The important principles to be kept in mind by any community which proposes to improve its roads are: (a) that they shall be *properly located* or laid out on the ground, so that their grades may be such that animal or motive power may be applied upon them to the best advantage and without great loss of energy; (b) that they shall be *properly constructed*, the ground well drained, the road bed graded, shaped and rolled, and covered with the best surface material obtainable consistent with the price to be paid, in order that when completed, they shall be hard, smooth, comparatively level and fit for traffic at all seasons of the year; (c) that after completion they shall be *properly maintained* or kept constantly in good repair.

(a) Location of Roads.

The question of the proper location of a road which it is proposed to improve is one of the most important to be considered. Unfortunately, it has been the custom, in most portions of Indiana, to improve existing roads, many of which have steep grades too long to be reduced by cutting and filling on the present lines, rather than relocating the road so as to obtain a more level surface.

Many of our roads were originally laid out without any attention to general topography, and in most cases followed the settler's path from cabin to cabin, the pig trail, or ran along the boundary lines of the farms regardless of grades or direction. Most of them remain today where they were located years ago, and where untold labor, expense and energy have been wasted in trying to haul over them and in endeavors to improve their deplorable condition. Samuel W. Foss in his poem entitled "The Calf-Path," has shown in his humorous style the gradual evolution of such crooked highways and the loss of time and energy which they entail upon the multitude which follow them. Since the poem seems very apropos in this connection I give it in full.

THE CALF-PATH.

"One day through the primeval wood
A calf walked home as good calves should;
But made a trail all bent askew,
A crooked trail as all calves do.
Since then three hundred years have fled,
And I infer the calf is dead.

"But still he left behind his trail,
And thereby hangs my moral tale.
The trail was taken up next day
By a lone dog that passed that way;
And then a wise bell-wether sheep
Pursued the trail o'er vale and steep,
And drew the flocks behind him, too,
As good bell-wethers always do.
And from that day o'er hill and glade,
Through those old woods a path was made.

"And many men wound in and out,
And dodged and turned and bent about,
And uttered words of righteous wrath
Because 'twas such a crooked path;
But still they followed--do not laugh—
The first migrations of that calf,
And through this winding woodway stalked
Because he wabbled when he walked.

"This forest path became a lane,
That bent and turned and turned again;
This crooked lane became a road,
Where many a poor horse with his load
Toiled on beneath the burning sun,
And traveled some three miles in one.
And thus a century and a half
They trod the footsteps of that calf.

"The years passed on in swiftness fleet,
The road became a village street;
And this, before men were aware,
A city's crowded thoroughfare.
And soon the central street was this
Of a renowned metropolis;
And men two centuries and a half
Trod in the footsteps of that calf.

"Each day a hundred thousand rout
Followed this zigzag calf about,
And o'er his crooked journey went
The traffic of a continent.
A hundred thousand men were led
By one calf near three centuries dead.
They followed still his crooked way,
And lost one hundred years a day;
For thus such reverence is lent
A well-established precedent.

"A moral lesson this might teach
Were I ordained and called to preach;
For men are prone to go it blind
Along the calf-paths of the mind,
And work away from sun to sun
To do what other men have done.
They follow in the beaten track,
And out and in, and forth and back,
And still their devious course pursue,
To keep the path that others do.
They keep the path a sacred groove,
Along which all their lives they move;
But how the wise old wood-gods laugh,
Who saw the first primeval calf.
Ah, many things this tale might teach—
But I am not ordained to preach."

Concerning these crooked highways and the location of improved roads M. O. Eldridge has some excellent advice in his work, entitled "Good Roads for Farmers," from which the following quotations are given:

"The great error is made of continuing to follow these primitive paths with our public highways. The right course is to call in an engineer and throw the road around the end or along the side of steep hills, instead of continuing to go over them; or to pull the road up on dry, solid ground instead of splashing through the mud and water of the creek or swamp. Far more time and money have

been wasted in trying to keep up a single mile of one of these 'pig-track' surveys than it would take to build and keep in repair two miles of good road.

"Straight roads are the proper kind to have, but in hilly countries their straightness should always be sacrificed to obtain a level surface so as to better accommodate the people who use them. Graceful and natural curves conforming to the lay of the land add beauty to the landscape, besides enhancing the value of property. Not only do level curved roads add beauty to the landscape and make lands along them more valuable, but the horse is able to utilize his full strength over them; furthermore, a horse can pull only four-fifths as much on a grade of two feet in 100 feet, and this gradually lessens until with a grade of 10 feet in 100 feet, he can draw but one-fourth as much as he can on a level road. Good roads should, therefore, wind around hills instead of running over them, and in many cases this can be done without greatly increasing the distance.

"The difference in length between a straight road and one which is slightly curved is less than one would imagine. Says Sganzin: 'If a road between two places ten miles apart were made to curve so that the eye could see no farther than a quarter of a mile of it at once, its length would exceed that of a perfectly straight road between the same points by only about 150 yards.' Even if the distance around a hill be much greater, it is often more economical to construct it that way than to go over and necessitate the expenditure of large amounts of money in reducing the grade, or a waste of much valuable time and energy in transporting goods that way. The mathematical axiom that 'a straight line is the shortest distance between two points' is not, therefore, the best rule to follow in laying out a road; better is the proverb that 'the longest way round is the shortest way home.'"

One of the most common mistakes in laying out the existing roads in Indiana was that many of them were made to follow section lines. These sections are all square, with sides running north, south, east and west. A person wishing to cross the country for any distance must, therefore, zigzag from one point of the compass to another. Moreover, such roads make necessary very often the crossing and recrossing of creeks and valleys, which might have

been avoided if the roads had been constructed on scientific principles. By noting on old maps the early Indian trails of the State it will be seen that they ran diagonally and did not follow the cardinal points. They were made as the crow flies—to get somewhere in the quickest time—and such diagonal roads across country would, in many instances, have been a great time saver to the present inhabitants of the State.

In southern Indiana, where the topography is much more broken than in the north, the question often arises as to the policy of keeping the roads on the ridges between the main streams, or of placing them in the valleys. Each location has its advantages. The ridge or divide roads in general have dry foundations. They require no outlay for bridges or for repair of damage done by flood waters. They can in many places be made more direct between chosen points. On the other hand, unless the ridge or table land be very wide and the valleys narrow, a large part of the transportation has to be up hill over the poorer roads which lead from the farms to the main highway. Moreover, in times of drought, such ridge roads are apt to become very dusty and to lack water supply for horses.

Valley roads often possess wet foundations and require large outlay for bridges and for repairing injury from floods. This latter objection is much more important in the locating of a stone road than generally supposed, as where flood waters, even of slight current, pass over a macadamized road they often remove the cementing material to the depth of several inches below the surface, and so reduce the roadway to a state of rubble which will not cement until properly repaired. It takes a much longer time for the tread of wheels and pounding of hoofs to produce new dust for cementing from the washed and rounded bits of old stone than from the sharp edges of newly laid macadam.

Taking the above facts into consideration it will be found best, where the valleys are narrow and the uplands broad, to build the roads on the ridges, leaving the limited farming area in the valleys to bear the tax of transportation to the upland. On the other hand, where the divides are narrow and the greater part of tillable land is on the slopes, the road had best be constructed in the valley or, if they will there be subjected to much overflow, on the lower sides

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Taking the above facts into consideration it will be found best, where the valleys are narrow and the uplands broad, to build the roads on the ridges, leaving the limited farming area in the valleys to bear the tax of transportation to the upland. On the other hand, where the divides are narrow and the greater part of tillable land is on the slopes, the road had best be constructed in the valley or, if they will there be subjected to much overflow, on the lower sides

of the ridges, just above the flood plains. In fact, the foot of the slope where it meets such plain is, in general, the better location for most valley roads, as there the foundation is generally good, being a talus of broken stone, stiff clay or gravel which has worked down from the hills. Moreover, in this position the stream gorges are usually narrow and not very deep, thus requiring a smaller outlay for bridges. The road should, however, be far enough away from the side of the ridge or hill that it will not be covered by land slides or slipping of earth or rock down the slope during the thawing seasons.

In northern Indiana, where the surface is deeply mantled with glacial drift, the valleys of the smaller streams and the table-lands between them are covered by irregularly disposed masses of debris which, in many places, give the surface a broken character, thus requiring great care in locating a road in order to avoid unnecessary grades. Moreover, in this part of the State the underlying material varies much in character, sometimes being very clayey, again very sandy, and in some places a muck or marl, which has seemingly no bottom. Under such conditions, the superintendent or road-master should study carefully the topography and the character of the underlying materials before settling definitely the final location of the road. Wherever the soil is deep, and therefore of a high order of fertility, road making is more costly for the reason that some provision similar to that of Telford* has to be provided to keep the surface coating of broken stone or gravel from working down into the foundation. In general, it may be said that the richer the soil the more costly the road; but, in turn, the community is usually the better able to pay for it.

A good superintendent will carefully study the underlying material at all doubtful points, by means of pits or cross sections. In this way he can decide as to the relative wetness of the under-earth and can the better locate the necessary drains and culverts. In many parts of the State existing roads have been constructed across swampy places or over patches of soft clay without any consideration as to the cost of maintaining them in such positions. As a consequence, costly fillings are constantly required, the expense of which could easily have been avoided by a little care in making the first location.

*See p. 21.

To insure reasonable grades, especially in a glaciated region, many cuts and fills have to be made. Care should be taken to bring these into such relation that the earth which is excavated can be used in constructing the fills and so lowering the grade.

In any region of the State which is more or less broken or varied in topography it is rarely that a stretch of five miles of road exists which does not show some noticeable error of location which, if avoided, would have saved time for every traveler, or expense in annual repair. In many cases the wrong placement of the route has been due to the influence of some land owner over or alongside whose property the route has perhaps been laid out through some wornout field or rocky knoll; or has cut around the farm line in order to prevent its passage through the more level and better tillable portion. In this manner the private individual has been allowed a slight personal gain at the cost of the remainder of the community and to the disadvantage of all future travel, traffic and commerce along the road.

Finally, it may be said that the task of planning and building any road in such a manner that the utmost advantage may be had from the conditions of the ground and from the material to be used is one of much difficulty, and demands the services of a well educated engineer who has devoted much time to highway work. With all other forms of construction it is possible for a man generally well informed in building to apply, in the manner of a copyist, the methods which have proved successful in other places. It is the peculiarity of a road, as compared with other architectural work, that it depends for its utility in greater measure on the topography and other earth conditions than any other constructive undertaking. Therefore the best advice that can be given to those who are about to engage in road-building is that they seek at once the assistance of the most successful highway engineer who can be obtained.

(b) Grading of Roads.

Whatever the material used in the construction of improved roads, steep grades should always be avoided when possible. During the winter season they often become covered with a coating of ice, or slippery soil, making them very difficult to ascend with heavy loads, and dangerous to descend under any conditions. The

degree of slipperiness at such a time depends largely upon the degree of smoothness. Therefore the smoother the road surface the less the grade should be. Moreover, such grades allow water to rush down them with such velocity as to wash great gaps along their sides and often to carry away much of the surfacing and cementing material.

It is also a well known fact that the loss of energy due to grades increases rapidly with their steepness; therefore, one hill on a long stretch of road often necessitates either the hauling of a smaller load or the use of more horses or other power. Gillespie in his "Manual of the Principles and Practice of Road Making," shows that if a horse can pull on a level 1,000 pounds, on a rise of—

One foot in 100 feet he can draw only	900
One foot in 50 feet he can draw only	810
One foot in 44 feet he can draw only	750
One foot in 40 feet he can draw only	720
One foot in 30 feet he can draw only	640
One foot in 25 feet he can draw only	540
One foot in 24 feet he can draw only	500
One foot in 20 feet he can draw only	400
One foot in 10 feet he can draw only	250

It is therefore seen that when the grades are one foot in 44 feet or 120 feet to the mile, a horse can only draw three-fourths as much as he can on a level; where the grade is one foot in 24 feet, or 220 feet to the mile, he can draw only one-half as much, and on a 10 per cent. grade, or 520 feet to the mile, he is able to draw only one-fourth as much as on a level road. The cost of haulage is, therefore, necessarily increased in proportion to the roughness of the surface or steepness of the grade. It costs one and a half times as much to haul over a road having a 5 per cent. grade and three times as much over one having a 10 per cent. grade as on a level road.

As to the limit of grade allowable, Eldridge states that "The proper grade for any particular road must be determined by the conditions and requirements existing on that road. The ideal grade is, of course, a level, but as the level road can seldom be obtained in rolling countries it is well to know the steepest allowable grades for ordinary travel.

"It has been found by experiment that a horse can, for a short time, double his usual exertion. From the above table we find that

a horse can draw only about one-half as much on a 4 per cent. grade as he can on a level road. As he can double his exertion for a short time, he can pull twice as much more, and the slope or grade which would force him to draw that proportion would therefore be a 4 per cent. grade. On this slope, however, he would be compelled to double his ordinary exertion to draw a full load, and this will therefore be the maximum grade if full loads are to be hauled. Most road builders prefer 3 per cent. grades to those of 4 per cent. where they can be secured without additional expense, but in some places it is necessary, for various reasons, to increase the grade to 5 per cent. With the exception of mountainous regions, where steeper grades are often unavoidable, the aim should be, on all public highways which are traveled by heavily loaded vehicles, to keep the grade down to 3 or 4 per cent. and never let it exceed 5 per cent."*

(c) Drainage of Roads.

The durability of any improved road depends very largely upon the making and maintaining of a solid, dry foundation. Water is the great road destroyer, therefore there is absolute necessity of sufficient drainage to carry away rainfall and melting snow. Potter, in his work entitled "The Road and the Roadside," states that "Very few people know how great an amount of water falls upon a country road, and it may surprise some of us to be told that on each mile of an ordinary country highway three rods wide within the United States there falls each year an average of 27,000 tons of water. In the ordinary country dirt road the water seems to stick and stay as if there was no other place for it, and this is only because we have never given it a fair opportunity to run out of the dirt and find its level in other places. We can not make a hard road out of soft mud, and no amount of labor and machinery will make a good road that will stay good unless some plan is adopted to get rid of the surplus water."

Hundreds of miles of macadam or gravel road are being built each year in Indiana on poorly drained or unstable foundations, and almost as many miles go to pieces on account of poor drainage. The importance of drainage has been well emphasized in the statement that "the three prime essentials to good roads are: first, drain-

*Farmers' Bulletin 136, U. S. Dept. Agr., p. 6.

age; second, better drainage; third, the best drainage possible." In general, it may be said that the *surface drainage* of a road should be so planned that no water can, under any conditions, flow from beyond the road upon its surface. The road-bed should be "crowned," or rounded up toward the center, that there may be a fall from the center to the sides, so that the water which falls within the improved way may be discharged into side ditches or gutters, and pass from those ditches into freer channels as soon as possible. No water should be allowed to flow across the roadway, except through culverts, tile, stone or box drains, which should be provided for that purpose. Furthermore, the underlying earth or foundation should be effectively kept dry to a depth below the frost level, or at least three feet below the crown of the road. This is termed the *subdrainage*.

Surface Drainage.—"The wearing surface of a road must be in effect a roof; that is, the section in the middle should be the highest part and the traveled roadway should be made as impervious to water as possible, so that it will flow freely and quickly into the gutters or ditches alongside. The best shape for the cross section of a road has been found to be either a flat ellipse or one made up of two plane surfaces sloping uniformly from the middle to the sides and joined in the center by a small circular curve. Either of these sections may be used, provided it is not too flat in the middle for good drainage or too steep at the gutters for safety. The steepness of the slope from the center to the sides should depend upon the nature of the surface, being greater or less according to its roughness or smoothness. This slope ought to be greatest on earth roads, perhaps as much in some cases as one foot in 20 feet after the surface has been thoroughly rolled or compacted by traffic This varies from about one in 20 to one in 30 on a macadam road to one in 40 or one in 60 on the various classes of pavements, and for asphalt sometimes as low as one in 80.

"Where the road is constructed on a grade or hill, the slope from the center to the sides should be slightly steeper than that on the level road. The best cross section for roads on grades is the one made up from two plane surfaces sloping uniformly from the center to the sides. This is done so as to avoid the danger of overturning near the side ditches, which would necessarily be increased

if the elliptical form were used. The slope from the center to the sides must be steep enough to lead the water into the side ditches instead of allowing it to run down the middle of the road. Every wheel track on an inclined roadway becomes a channel for carrying down the water, and unless the curvature is sufficient, these tracks are quickly deepened into water courses, which cut into and sometimes destroy the best improved road.

"On ground with good natural underdrainage, as on hillsides, surface ditches are sufficient to carry off surface water from rain or snow. In order to prevent washouts on steep slopes, however, it sometimes becomes necessary to construct water breaks; that is, broad, shallow ditches so arranged as to catch the surface water and carry it each way into the side ditches. Unfortunately, some road builders have an idea that the only way to prevent hills, long and short, from washing, is to heap upon them a large number of those ditches known in different sections of the country as 'thank-you-ma'am's', 'breaks', or 'hummocks', and the number they sometimes squeeze in upon a single hill is astonishing. Such ditches retard traffic to a certain extent, and often result in overturning vehicles; consequently they should never be used until all other means have failed to cause the water to flow into the side channels. They should never be allowed to cross the entire width of the road diagonally, but should be constructed in the shape of the letter V, with the point up hill. This arrangement permits teams following the middle of the road to cross them squarely, and thus avoid the danger of overturning. These ditches should not be deeper than is absolutely necessary to throw the water off the surface, and the part in the center should be the shallowest.

"The size of side ditches should depend upon the character of the soil and the amount of water they are expected to carry. If possible, they should be located three feet from the edge of the traveled roadway, so that if the latter is 14 feet wide there will be 20 feet of clear space between the ditches.

"To make a ditch with even flaring sides, so as to produce a neat job, it is good policy to use a rough gauge. The gauge is made of light strips of wood about three inches in width and one inch thick. The upright strip should be about four feet long, and the horizontal strip should be 18 inches in length, measured from the

left side of the upright piece to the point of the gauge on the extreme right. The top of the horizontal strip should be one foot from the bottom point of the gauge. This gauge should be pro-

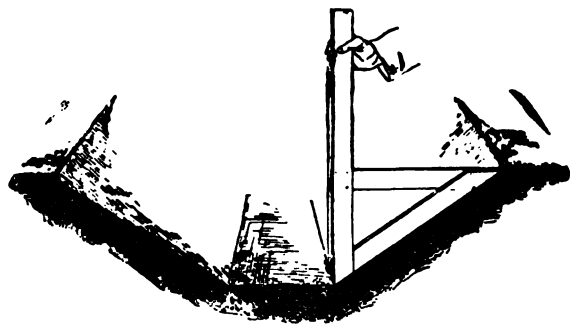

Fig. 9. Proper form of surface ditch, showing manner of construction.

vided with a plumb and line, and by means of the upright strip is held vertical while the slope is made to correspond with the edges of the diagonal strip.

"The bottom of the ditch may vary in width from 3 to 12 inches, or even more, as may be found necessary in order to carry the largest amount of water which is expected to flow through it at any one time. Sometimes the only ditches necessary to carry off the surface water are those made by the use of the road machines or road graders. The blade of the machine may be set at any desired angle, and when drawn along by horses cuts into the surface and moves the earth from the sides toward the center, forming gutters alongside and distributing the earth uniformly over the traveled way. Such gutters are liable to become clogged by brush, weeds and other debris, or destroyed by passing wagons, and it is therefore better, when the space permits, to have the side ditches above referred to, even if the road be built with a road machine."*

Sub-Drainage.—It can not be too often repeated, that the surface of any gravel or stone road should be in effect a roof; and that the section or foundation below it should be kept by that surface or cover in a perfectly dry state. It is also just as necessary that water should be prevented from entering the sub-structure or

*Farmers' Bulletin No. 95, pp. 14-17.

foundation from the side as that it should be kept from percolating through it from above. If water is allowed to enter and remain in the foundation during winter the whole roadway is liable to become broken up and destroyed by frost and traffic. The common side ditches collect and carry off the surface water only. Where the roads pass through low, wet areas or over certain kinds of clayey soil, sub-drainage therefore becomes necessary. On this subject Potter has written as follows:

"Many miles of road are on low, flat lands and on springy soils, and thousands of miles of prairie roads are, for many weeks in the year, laid on a wet sub-soil. In all such cases, and, indeed, in every case where the nature of the ground is not such as to insure quick drainage, the road may be vastly benefited by under-drainage. An under-drain clears the soil of surplus water, dries it, warms it, and makes impossible the formation of deep, heavy, frozen crusts, which are found in every undrained road where the severe winter weather follows the heavy fall rains. This frost causes nine-tenths of the difficulties of travel in the time of sudden or long continued thaws.

"Roads constructed over wet undrained lands are always difficult to manage and expensive to maintain, and they are liable to be broken up in wet weather or after frosts. It will be much cheaper in the long run to go to the expense of making the drainage of the subjacent soil and substructure as perfect as possible. There is scarcely a road in the United States which can not be so improved by surface or sub-drainage as to yield benefits to the farmers a hundred times greater in value than the cost of the drains themselves.

"Under-drains are not expensive. On the contrary, they are cheap and easily made, and if made in a substantial way and according to the rules of common sense a good under-drain will last for ages. Sub-drains should be carefully graded with a level at the bottom to a depth of about four feet, and should have a continuous fall throughout their entire length of at least six inches for each 100 feet in length. If drain tiles can not be had, large, flat stones may be carefully placed so as to form a clear, open passage at the bottom for the flow of the water. The ditch should then be half filled with rough field stones, and on these a layer of smaller stones

or gravel and a layer of sod, hay, gravel, cinders or straw, or, if none of these can be had, of soil. If field stones or drain tile can not be procured, satisfactory results may be attained by the use of

Fig. 10. Subdrain made of bundles of brush for conveying spring water under or alongside roads.

Fig. 11. Subdrain made of field stone for conveying spring water under or alongside of roads.

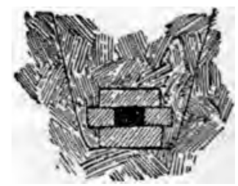

Fig. 12. Subdrain made of bricks for conveying spring water under or alongside of roads.

logs and brush. If there be springs in the soil which might destroy the stability of the road, they should, if possible, be tapped

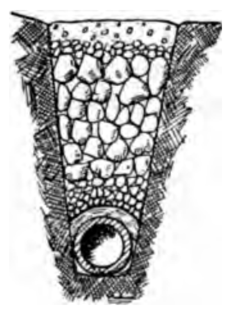

Fig. 13. Subdrain constructed with drain tile and stone.

and the water carried under or along the side until it can be turned away into some side channel."

Culverts.—The smaller waterways which every improved road must cross should be provided for by means of culverts, and great care should be taken to insure sufficient room for easy passage of the flood waters which are sure to prevail at some season of the year. These culverts are now easily, cheaply and durably constructed of concrete. The best quality of Portland cement and broken limestone should be used in their building. Under no circumstances should water be impounded along the roadway in such a manner that a heavy rainfall will cause it to flow over the road. The effect of such overflow on a macadam road will quickly wash

away the cementing material and convert the surface into a mass of rubble, which is also apt to wash away. A close reckoning should, therefore, be made of the area drained by any culvert, and full allowance be made for free passage of the maximum precipitation.

(*d*) *The Construction of Gravel Roads.*

In the building of either gravel or stone roads, the bed or foundation on which the hard material is to be placed, after being graded and provided with sufficient drainage outlets, should be rolled with either a steam roller or a heavy horse roller, in order to bring it to an even, compact state. The practice of rolling both the bed and the surface material has been practiced on few, if any, roads in Indiana, and as a consequence, their durability has been greatly impaired. By rolling, the base of the road is made firm and solid, and the gravel or broken stone thus kept from working down into the bed.

The gravel to be used in surfacing the road should be chosen with care as to its quality.

Many of the so-called gravel roads are, in reality, constructed largely of sand. Good gravel rarely contains more than one-fourth part of sand or clay, and does not show a trace of slipping after freezing. Where the walls of the pit are so firm that they remain steep after exposure for a winter, the material requires no other treatment except the removing of pebbles which are more than two inches in diameter.

There are various methods of building gravel roads in Indiana, and as a consequence the roads vary much in quality and durability. In a large number of cases gravel is used, one-half or more of which would pass through a three-eighths-inch screen. This mixture of sand and gravel is dumped irregularly into ruts, mudholes or gutter-like depressions on an imperfectly graded and drained foundation, and left for traffic to spread and consolidate. The contractor pockets the profit—which is large—and the farmers have on their hands for maintenance a road which is little better than before. This is a common but very poor method of gravel road construction.

Eldridge, in his "Good Roads for Farmers," gives the following directions for an up-to-date method by which an excellent and durable road of gravel can be built:

"*Grade and Width of Gravel Roads.*—In constructing a gravel road the roadbed should first be brought to the proper grade. An excavation should then be made to the depth of eight or ten inches, varying in width with the requirements of traffic. For a farming community the width need not be greater than ten or twelve feet; for a highway, fourteen feet. The surface of the roadbed should preferably have a fall from the center to the sides the same as that to be given the finished road, and should, if possible, be thoroughly rolled and consolidated until perfectly smooth and firm.

"A layer, not thicker than four inches, of good gravel should then be spread evenly over the prepared roadbed. Such material is usually carried upon a road in wheelbarrows or dump carts, and then spread in even layers with rakes, but the latest and best device for this purpose is a spreading cart.

"*Rolling the Road.*—If a roller can not be had, the road is thrown open to traffic until it becomes fairly well consolidated; but it is impossible to properly consolidate materials by the movement of vehicles over the road, and if this means is pursued constant watchfulness is necessary to prevent unequal wear and to keep the surface smooth and free from ruts. The work may be hastened and facilitated by the use of a horse roller or light steam roller; and of course far better results can be accomplished by this means. If the gravel be too dry to consolidate easily it should be kept moist by sprinkling. It should not, however, be made too wet, as any earthy or clayey matter in the gravel is liable to be dissolved.

"As soon as the first layer has been properly consolidated a second, third, and, if necessary, fourth layer, each three or four inches in thickness, is spread on and treated in the same manner until the road is built up to the required thickness and cross section. The thickness in most cases need not be greater than 10 or 12 inches, and the fall from the center to the sides ought not to be greater than one foot in 20 feet, or less than one in 25 feet.

"The last, or surface, layer should be rolled until the wheels of heavily loaded vehicles passing over it make no visible impression. If the top layer is deficient in binding material and will not properly consolidate, a thin layer, not exceeding one inch in thickness, of sand or gravelly loam or clay should be evenly spread on and slightly sprinkled, if in dry weather, before the rolling is begun.

Hardpan or stone screenings are preferred for this purpose if they can be had.

"The tendency of the material to spread under the roller and work toward the sides can be resisted by rolling that portion nearest the gutters first. To give the surface the required form and to secure uniform density it is necessary at times to employ men with rakes to fill any depressions which may form.

"*Maintenance.*—In order to maintain a gravel road in good condition, it is well to keep piles of gravel alongside at frequent intervals, so that the person who repairs the road can get the material without going too far for it. As soon as ruts or holes appear on the surface some of this good, fresh material should be added and tamped into position or kept raked smooth until properly consolidated.

"If the surface needs replenishing or rounding up, as is frequently the case with new roads after considerable wear, the material should be applied in sections or patches, raked and rolled until hard and smooth.

"Care must be taken that the water from the higher places does not drain on to or run across the road. The side ditches, culverts and drains should be kept open and free from debris."

Gravel roads, in general, take more time to come into good condition than stone roads. Rarely do they show at their best until after they have been in use for several years, meanwhile being subject to frequent repairs. If a good gravel be used on a carefully graded and drained subway, a country road may be built which, while it will not last as long as a properly constructed stone road, will cost much less originally or for annual maintenance. A number of the gravel roads in the central and northern counties of Indiana have been in use 20 or more years and are today in excellent condition. On the other hand, broken stone will be found preferable on the main highways where there is a constant and heavy traffic, or in districts where the supply of gravel is limited or poor in quality.

(e) *The Construction of Macadam Stone Roads.*

In those localities of the State where limestone of good quality is readily obtained, it has been found well adapted as a material for surfacing the country roads and highways. All things con-

sidered, first cost, maintenance and efficiency, it has proven and will prove the best and cheapest material for the purpose. Among its advantages are ease of application, a hard, smooth surface which is impervious to water, and ease of repair when properly made. It has the disadvantage of becoming dusty in dry, and somewhat muddy in wet weather, but these are not serious faults.

Fig. 14. Cross section of macadam road showing a compact foundation of earth supporting a solid and durable stone surface.

As we have noted, there are three essential factors in the building of a lasting road of either gravel or stone, viz.: (a) good foundation; (b) good drainage; (c) good material. A fourth, and equally essential, especially in stone roads, is that of the proper preparation and placing of the material on the roadbed. Under the old method of preparing macadam material with a hammer, by hand, the cost of breaking the stone was the heaviest expense in building the road. In the modern system by use of the jaw-crusher, operated by steam power, stone may be prepared at a cost of 30 to 40 cents per cubic yard, as against 75 cents to $1.50 by the hammer. Where the township or county owns the crusher, the total cost of quarrying and breaking the stone need not exceed 60 cents per yard.

As noted in a preceding section,* any stone employed for surfacing roads should be both hard and tough, and should possess both cementing and recementing qualities. Many of the limestones described under the subsequent sections possess these qualities in sufficient degree and are being or will be used on many hundreds of miles of roads in the State.

The method of preparing the broken stone has been well treated by Potter; and its application according to the most approved methods, by Eldridge, hence I quote in full from these writers concerning these methods as follows:

"*Handbreaking of Stone.*—It is a simple task to break stone for macadam roadways, and by the aid of modern inventions it can be done cheaply and quickly. Handbroken stone is fairly out of date

*See p. 57.

and is rarely used in America where any considerable amount of work is to be undertaken. Stone may be broken by hand at different points along the roadside where repairs are needed from time to time, but the extra cost of production by this method forbids its being carried on where extended work is undertaken. Hand-broken stone is generally more uniform in size, more nearly cubical in shape, and has sharper angles than that broken by machinery, but the latter, when properly assorted or screened, has been found to meet every requirement.

"*Stone Crushers.*—A good crusher driven by eight horse-power will turn out from 40 to 80 cubic yards of two-inch stone per day of ten hours, and will cost from $400 upward, according to quality.

"Crushers are made either stationary, semi-stationary or portable, according to the needs of the purchaser, and for country road work it is sometimes very desirable to have a portable crusher to facilitate its easy transfer from one part of the town to another. The same portable engine that is used in threshing, sawing wood and other operations, requiring the use of steam power, may be used in running a stone crusher, but it is best to remember that a crusher will do its best and most economical work when run by a machine having a horse-power somewhat in excess of the power actually required.

"*Screening the Stone.*—As the stone comes from the breaker the pieces will be found to show a considerable variety in size, and by many practical roadmakers it is regarded as best that these sizes should be assorted and separated, since each has its particular use. To do this work by hand would be troublesome and expensive, and screens are generally employed for that purpose. Screens are not absolutely necessary, and many roadmakers do not use them; but they insure uniformity in size of pieces, and uniformity means in many cases superior wear, smoothness and economy. Most of the screens in common use today are of the rotary kind. In operating, they are generally so arranged that the product of the crusher falls directly into the rotary screen, which revolves on an inclined axis and empties the separate pieces into small bins below the crusher. A better form for many purposes includes a larger and more elaborate outfit, in which the stone is carried by an elevator to the screen and by the screen emptied into separate bins, according to the respective sizes. From the bins it is easily loaded into wagons

or spreading carts and hauled to any desired point along the line of the road.

"The size to which the stone should be broken depends upon the quality of the stone, the amount of traffic to which the road will be subjected, and to some extent upon the manner in which the stone is put in place. If a hard, tough stone is employed it may be broken into rough cubes or pieces of about one and a half inches in largest face dimensions, and when broken to such a size the product of the crusher may generally be used to good advantage without the trouble of screening, since dust 'tailings' and fine stuff do not accumulate in large quantities in the breaking of the tougher stone.

"If only moderate traffic is to be provided for, the harder limestones may be broken so the pieces will pass through a two-inch ring, though sizes running from two and a quarter to two and a half inches will insure a more durable roadway, and if a steam roller is used in compacting the metal it will be brought to a smooth surface without much trouble. As a rule, it may be said that to adhere closely to a size running from two and a quarter to two and a half inches in largest face dimensions, and to use care in excluding too large a proportion of small stuff as well as all pieces of excessive size will insure a satisfactory and durable macadam road.*

"*Application of the Material.*—The evils from improper construction of stone roads are even greater than those resulting from the use of improper material. Macadam never intended that a heterogeneous conglomeration of stones and mud should be called a macadam road. The mistake is often made of depositing broken

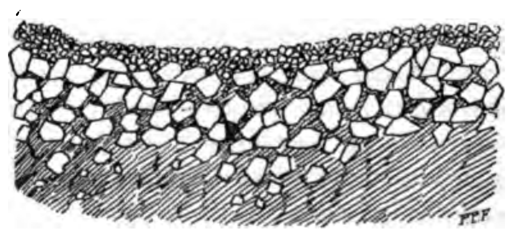

Fig. 15. Cross section of macadam road showing result of placing stone on loose or wet earth foundation.

stone on an old road without first preparing a suitable foundation. The result, in most cases, is that the dirt and mud prevent the

*Potter, "The Road and the Roadside," pp. 83-94.

stone from packing, and by the action of traffic ooze to the surface, while the stones sink deeper and deeper, leaving the road as bad as before.

"Another great mistake is often made of spreading large and small stones over a well graded and well drained foundation and leaving them thus for traffic to consolidate. The surface of a road left in this manner is often kept in constant turmoil by the larger stones, which work themselves to the surface and are knocked

Fig. 16. Bad condition of road resulting from attempt at macadam construction with large and small broken stone. Large stones have worked out to the surface.

hither and thither by the wheels of the vehicles and the feet of animals. These plans of construction can not be too severely condemned.

"The roadbed should be first graded, then carefully surface-drained. The earth should then be excavated to the depth to which the material is to be spread on, and the foundation properly shaped and sloped each way from the center so as to discharge any water which may percolate through. This curvature should conform to the curvature of the finished road. A shouldering of firm earth or gravel should be left or made on each side to hold the material

in place, and should extend to the gutters at the same curvature as the finished road. The foundation should then be rolled until hard and smooth."*

"Upon this bed spread a layer of three or four inches of broken stone, which stone should be free from any earthy mixture. This layer should be thoroughly rolled until compact and firm. Stone may be hauled from the stone crusher bins or from the stone piles in ordinary wheelbarrows or farm wagons, and should be distributed broadcast over the surface with shovels, and all inequalities leveled up by the use of rakes. If this method of spreading is employed, grade stakes should be used so as to insure uniformity

Fig. 17. Spreading cart for distributing macadam material.

of thickness. After the stakes are driven the height of the layer is marked on their sides, and a piece of stout cord is stretched from stake to stake, showing the exact height to which the layer should be spread. Spreading carts are in use in some places which not only place the stone where it is needed without the use of shovels, but spread it on in layers of any desired thickness.

*In some of the counties of northwestern Indiana where there is a thick surface bed of sand, some hardening of the surface will be found necessary, else the roller or the traffic will churn the sand and broken stone together until half of the stone will be lost. In these counties it may be found profitable to adopt the method used by the Massachusetts Highway Commission of placing cheesecloth on the sand after the road is shaped to receive the broken stone. This effectively prevents the sand and stone from mingling during the process of rolling or compacting the latter. The Commission mentioned paid three cents per square yard for the cheesecloth. This for a roadway 15 feet in width amounted to about $750 per mile; but even this was less than any other effective method of attaining the object sought, and was less than one-third that due to the loss of the broken stone which would occur if it were allowed to come directly in contact with the sand. For further particulars see Shaler, "American Highways," p. 155.

"If the stones have been separated into two or three different sizes the largest size should compose the bottom layer, the next size the second layer, etc. The surface of each course or layer should be thoroughly and repeatedly rolled and sprinkled until it becomes firm, compact and smooth. The first layer, however, should not be sprinkled, as the water is liable to soften the foundation. The rolling ought to be first done along the side lines, gradually working towards the center as the job is being completed. In rolling the last course it is well to begin by rolling first the shoulderings or the side roads if such exist.

"A coat of three-quarter-inch stone and screenings, of sufficient thickness to make a smooth and uniform surface, should compose the last course, and, like the other layers, should be rolled until perfectly firm and smooth. As a final test of perfection, a small stone placed on the surface will be crushed before being driven into the material.

"If none of the stones used be larger than will pass through a two-inch ring they can be spread on in layers as above described without separating them by screens. Water and binding material —stone screenings or good packing gravel—can be added if found necessary for proper consolidation. Earth or clay should never be used for a binding material. Enough water should be sprinkled on to wash in and fill all voids between the broken stones with binding material, and to leave such material damp enough to insure its setting or compacting.

"*Rollers.*—If a road is built of tough, hard stone, and if the binding material has the same characteristics, a steam roller is essential for speedy results. A horse roller may be used to good advantage if the softer varieties of stone are employed. For gen-

Fig. 18. First course of stone on a macadam road as it appears when spread ready for rolling.

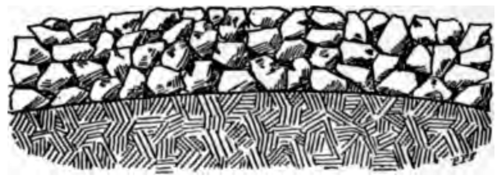

Fig. 19. First course of stone on a macadam road when partially rolled, showing how the roller packs it.

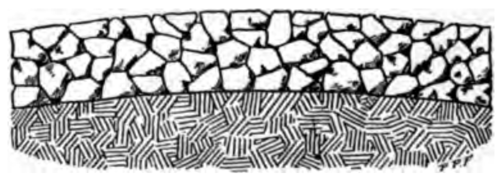

Fig. 20. Stone on a macadam road firmly wedged and packed together. Small stones, gravel, dirt or sand, if mixed with the stone or spread on the surface before rolling, prevent its being thoroughly wedged and packed.

eral purposes, a roller weighing from eight to twelve tons is sufficient in size. Heavier weights are difficult to handle upon unimproved surfaces."*

(*f*) *The Construction of Telford Stone Roads.*

As already noted, the most important difference between Macadam and Telford roads relates to the propriety or necessity of a paved foundation beneath the crust of broken stone. Telford advocated this principle, while Macadam strongly denied its advantages.

No properly constructed Telford roads have been built in Indiana. In several of the southern counties roads have been built by making the bottom course, five or six inches in thickness, of large pieces of stone and the upper portion of either gravel or smaller fragments of crushed stone. In no instance were the stones comprising the bottom layer properly laid, and in a number of cases they were of inferior material, such as sandstone or soft limestone. As a consequence the larger pieces have, in many places, worked up to the top and have made the road very rough and inferior in every way to macadam roads of the same region.

In general it may be stated that the more costly Telford method

*"Good Roads for Farmers," Far. Bull. No. 95 pp. 38-41. Figs. 9 to 21, inclusive, are reproduced from the same bulletin.

of construction should not be used except where the road passes through a low, wet region, difficult to drain by under-ditches. In a number of the northern counties of Indiana where the roadbed passes over the sites of old lakes or swamps, the Telford system will be found preferable. In many such places solid and reliable roadbeds can only be secured by the use of this system.

In making a Telford road the surface for the foundation is prepared in the same manner as for a macadam road. A layer of broken stone is then placed on the roadbed from five to eight inches in depth, depending upon the thickness to be given the finished road. As a rule this foundation should form about two-thirds of the total thickness of the material. The stone used for the first layer may vary in thickness from two to four inches and in length

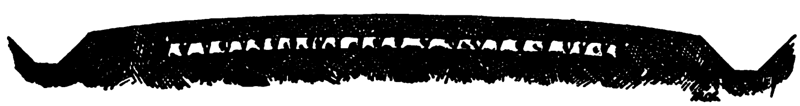

Fig. 21. Transverse section of telford road with macadam surface.

from eight to 12 inches. The thickness of the upper edges of the stones should not exceed four inches. They should be set *by hand* on their broadest edges lengthwise across the road, breaking joints as much as possible. All projecting points should then be broken off, the interstices or cracks filled with stone chips, and the whole structure wedged and consolidated into a solid and complete pavement. Upon this pavement layers of broken stones are spread and treated in the same way as for a macadam road.

(*g*) *The Maintenance of Improved Roads.*

All roads, whether of dirt, gravel or stone, require constant attention if they are to remain in good condition. The effects of travel or weather on the best of them are soon to be noticed.

The method, so common in Indiana, of not improving a road until it is in bad condition, is a very harmful one; for not only do the travelers have to put up with a poor road during the time of its bad condition, but the ultimate cost of repairs is much greater.

In France, where some of the best stone roads of the world occur, men are kept constantly at work making repairs as soon as needed. To each of these men, known as *cantonniers*, a section of a road is

assigned, to which he gives his entire time. He is expected to break and apply the stone needed, to attend to the ditches and drains, and to keep the sides of the road free from weeds and rubbish. Each man provides his own tools, and six or eight of them are under the charge of a chief, who has a shorter section of the road to look after, in order that he may give some time to the overseeing and directing of the subordinates. It is the same system that we see employed upon every railroad in the United States, where section hands are constantly at work, not only making repairs where there is a break, but ever strengthening the weaker spots to prevent the breaks. A section gang to each six or eight miles of railway is one of the first accessories or requirements of the newest and best railroads, as well as those of second and third class. Country roads and highways were in existence centuries before railways were dreamed of, and are of far greater importance to any farming community than are the latter. It would seem that the farmers would learn a lesson from the work of the section gangs, and apply the same principles of maintenance to the highways which they travel every day.

"A stitch in time saves nine" is a proverb which is especially adapted to the maintenance of roads. As soon as a depression or hollow appears in the road surface and is noticeable by the presence of a pool of water after a rain, the mud should be scraped from the hole and the latter refilled with broken stone or gravel, as the case may be, and then thoroughly tamped or rolled to form a surface uniform with the remainder of the roadway. If such depressions are allowed to go unrepaired, the collected water soon soaks into the road and softens the surface, so that each passing vehicle digs deeper and wider the rut. The bonds between the fragments of stone or gravel are loosened and they are easily displaced by the horses' hoofs. Once begun and neglected, this unraveling process goes on at a rapidly increasing rate. What in the beginning was a small depression, easily repaired with a few shovelfuls of stone, quickly develops into a large sized hole, requiring many times the material and labor to repair.

Oftentimes such a hole is filled up with large pieces of stone or gravel and left untamped. In most cases it would be better to dump such material into the side ditch than into the hole, since

such stones do not wear uniformly with the rest of the material, but produce lumps and ridges, and usually result in making two holes instead of filling one. Indeed, the result of any mending of a stone or gravel road depends largely on the skill of the workman making the repair so that the surface of the new portion may be exactly in its proper level. If higher or lower, the repair will be only temporary, since a pit will form in the old position if it be too low, or other pits will be formed alongside of it if the surface be left too high.

"Where the material of the road surface is very hard and durable, a well constructed road may wear quite evenly and require hardly any attention, beyond ordinary small repairs, until worn out. It is now usually considered the best practice to leave such a road to itself until it wears very thin, and then renew it by an entirely new layer of broken stone placed in the worn surface and without in any way disturbing that surface.

"If a thin layer only of material is to be added at one time, in order that it may unite firmly with the upper layers of the road, it is usually necessary to break the bond of the surface material before placing the new layer, either by picking it up by hand or by a steam roller with short spikes in its surface, if such a machine is at hand. Care should be taken in doing this, however, that only the surface layer be loosened, and that the solidity of the body of the road be not disturbed, as might be the case if the spikes are too long."

By the first of November of any year all improved roads built and thrown open to traffic prior to September first of that year, which have not been properly rolled or compacted, will be found to have three gullies or furrows along their surface, with two ridges intervening, and also with an additional ridge on each side. Two of the furrows are caused by the wheels of the vehicles and the hoofs of teams, while the third and more shallow one has been worn by the travel of horses hitched to single buggies. In these furrows the rainfall and melting snow of the coming winter and spring is sure to accumulate and weaken the surface covering. All new roads should be carefully gone over during November or December and the ridges leveled and the furrows filled, either by hand rakes or by passing some form of scraper with converging flanges over the

road, so that the materials of the ridges may be drawn back into the furrows from which they have been cast out by traffic. A simple and tolerably effective instrument for this purpose may be made by taking a large, heavy wagon tire and loading it with a bar of iron or other weight strapped across the middle. This, when dragged by a horse along the roadway, will level the surface. If a heavy roller could then be passed over the road several times it will be in fair condition for the first winter, which is the worst one, from a wear-out standpoint, which it usually has to undergo.

Wide tires should be used on all heavy vehicles which traverse improved roads. A four or five-inch gravel or stone road will last longer without repair when wide tires are used than an eight or ten-inch road of the same material where the heavy traffic is mainly by narrow-tired wagons. Wide tires not only prevent the cutting of roads into narrow ruts, but they are of advantage in compacting the surface. It has also been proven by careful tests that much heavier loads can be hauled by the same team or power on wide-tired wagons than on narrow-tired ones. These tests were made at the Missouri Agricultural Experiment Station, the reports showing that:

(1) "A large number of tests on meadows, pastures, stubble land, corn ground, and plowed ground in every condition, from dry, hard and firm to very wet and soft, show, without a single exception, a large difference in draft in favor of the broad tires. This difference ranged from 17 to 120 per cent.

(2) "Gravel road. In all conditions of the gravel road, except wet and sloppy on top, the draft on the broad-tired wagon was very much less than that of the narrow-tired wagon. Averaging the six trials, a load of 2,482 pounds could be hauled on the broad tires with the same draft required for a load of 2,000 pounds on the narrow tires."

All gutters, side ditches and other surface drains along improved roads should be kept open, by going over them at least once a year and removing the earth and other rubbish which has accumulated. More damage is done to roads by water which flows from filled up or imperfectly constructed ditches on to the roadway than by any other source. In several counties of southern Indiana where there were "cloud bursts" or excessive rainfalls in the summer of 1905, damage to the amount of thousands of dollars was done the roads by

water running down their center in great streams, simply because the side ditches had been neglected and were so filled up that they were useless. No weeds should be allowed to grow in these ditches, as their presence stops or retards the silt and mud being carried down, and their decay also adds to the rubbish which collects.

Finally, it may be said that repairs on the roads should be mainly done in the spring after the alternate freezing and thawing period has ended, for it is then that the weak spots are most easily found; but the great mistake of letting all repairs go till that time should not be made. The principal need of the improved road is daily care, and "the sooner we do away with the system of 'working out' our road taxes, and pay such taxes in money, the sooner will it be possible to build improved roads and to hire experts to keep them constantly in good repair. Roads could then secure attention when such attention is most needed. If they are repaired only annually or semi-annually they are seldom in good condition, but when they are given daily or weekly care they are most always in good condition, and, moreover, the second method costs far less than the first. A portion of all levy tax money raised for road purposes should be used in buying improved road machinery, and in constructing each year a few miles of improved stone or gravel roads."

(h) *The Cost of Improved Roads.*

The initial cost of an improved road depends upon the cost of material, labor, machinery, the width and depth to which the surface material is to be spread on, and the method of construction. All of these are variable factors—so much so that it is impossible to name the exact amount which a mile of a certain kind of road in any county will cost, unless the specifications are at hand.

From the statistics gathered from the different counties we find that the average mile of gravel road in the State heretofore constructed has cost $1,403 and the average mile of stone road $2,221. That these figures are too high, taking into consideration the quality of the roads put off on the people, no one will deny who has traveled over the roads of different parts of the State. In certain counties, as high as $4,000 per mile has been paid for gravel roads within the past five years; while many stone roads have

been let at $3,000 or more per mile. The average road contractor is not in business for his health, and where the county commissioners and county engineer are limited in knowledge as to road improvement or where they can be manipulated in any manner by the contractor, the public is apt to pay dearly for an inferior grade of improved road.

Where the surface material does not have to be hauled over four miles, the best of gravel roads should be built in Indiana for $1,500 per mile, and the best of limestone macadam roads for $2,000. Where the material has to be shipped in by rail from a distant source the additional cost should not exceed $200 per mile. These figures are in excess of those given by Prof. Latta in 1898, from data gathered from numerous farmers, as he estimated * that the average cost of converting the common public roads into improved highways would be $1,146 per mile. This cost was based largely upon estimates furnished for gravel roads, and principally in the northern part of the State where gravel is more plentiful than in the south. The price of labor and machinery is also higher now than then.

The prices paid for road improvement in certain other states has been given by Eldridge as follows: "First-class single track stone roads, 9 feet wide, have been built near Canandaigua, N. Y., for $900 to $1,000 per mile. Many excellent gravel roads have been built in New Jersey for $1,000 to $1,300 per mile. The material of which they were constructed was placed on in two layers, each being raked and thoroughly rolled, and the whole mass consolidated to a thickness of eight inches. In the same State macadam roads have been built for $2,000 to $5,000 per mile, varying in width from nine to 20 feet and in thickness of material from four to 12 inches. Telford roads 14 feet wide and 10 to 12 inches thick have been built in New Jersey for $4,000 to $6,000 per mile. Macadam roads have been built at Bridgeport and Fairfield, Conn., 18 to 20 feet wide, for $3,000 to $5,000 per mile. A Telford road 16 feet wide and 12 inches thick was built at Fanwood, N. J., for $9,500 per mile. Macadam roads have been built in Rhode Island, 16 to 20 feet wide, for $4,000 to $5,000 per mile.

*See p. 82.

(*i*) *The Construction of Vitrified Brick Roads.*

Within the past three years 58+ miles of the public roads of Cuyahoga County, Ohio, have been improved with vitrified brick as the surfacing material. From statistics kindly furnished me by Mr. Wm. H. Evers, County Surveyor, I learn that the total cost of these roads was $1,426,711, or an average of $24,500 per mile. These roads are all outside of the city of Cleveland, which is located in the county. The width of the paved portion is 14 feet, the average cost of the vitrified block used being $16.00 per thousand, and the average distance of hauling from the railway spurs, three miles. The following cut of a cross section of one of the roads shows the main features of its construction:

The roads were built under an Ohio law which provides that, in addition to the levy regularly authorized for road and bridge purposes, the county commissioners may assess an additional levy of one-half mill on each dollar of valuation of taxable property in the county, to provide a fund for the permanent improvement of state and county roads. From such fund 40 to 70 per cent. of the cost of such roads shall be paid, while not to exceed 60 per cent. shall be paid from the taxes raised by assessments against the land abutting the roads improved, such assessments to be paid in ten equal installments. No road shall be improved until after a petition, signed by the owners of a majority of the front-footage of land abutting such road, shall have been made.

The county commissioners of Cuyahoga County form an assessing board and have levied on the adjoining property of the various roads improved from 30 to 60 per cent. of the total cost of the same, according to benefits, paying the balance of the cost of the work out of the fund provided by the half-mill tax which, in that county, approximates $90,000 per annum. The traction railway companies along the thoroughfares are required to brick-pave a 15-foot strip for double tracks for a distance of four and a half miles.

Mr. Evers, in a recent address, stated that "Cuyahoga County will annually improve about ten miles of road, at an expense approximating $20,000 per mile. With this continual amount of work, in surfacing our highways, the county will soon have every main thoroughfare paved, and will endeavor to construct the same to conform to theoretical principles and the best practical experi-

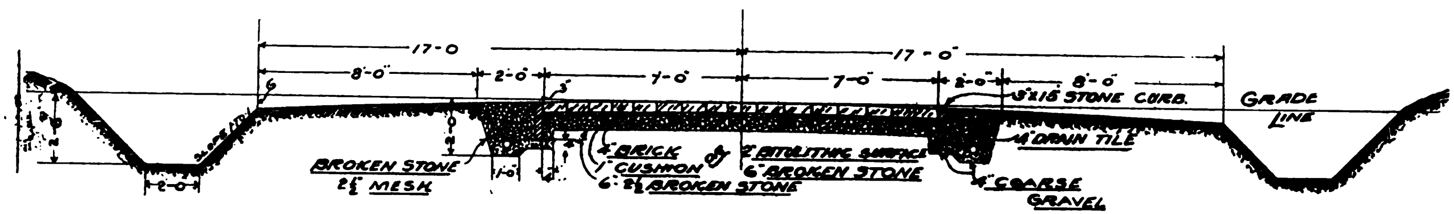

Fig. 22. Proposed cross section State Road No. 3, Parma and Royalton, April, 1905. Wm. H. Evers, C. E., County Engineer.

ences, so that the people of the Middle West can not only look to Cuyahoga County as the brick-paving center, but will be able to point to our methods of building roads as giving the best, the most permanent and popular improved highways."*

*For standard specifications for the construction of brick pavements or brick roads see the 29th (1904) Annual Report of this Department, p. 541.

SECTION V.

THE GEOLOGIC DISTRIBUTION OF THE ROAD MATERIALS OF INDIANA.

BY W. S. BLATCHLEY.

Compared with many other states, Indiana is rich in road building materials. While the northern two-thirds of the State is almost everywhere covered with a heavy mantle of drift which hides the underlying rocks and renders them unattainable for macadamizing purposes, much of this till or drift material is gravel of excellent quality which has long been more or less utilized for road improvement. Along the Wabash River and larger streams of this section of the State there are also, in places, a number of exposures of limestone, either Niagara or Corniferous, which have furnished and will continue to furnish large quantities of excellent road metal. In this northern Indiana region only a few counties in the extreme northwestern portion of the State are devoid of both gravel and stone and have to import all of the materials used in the improvement of their roads. These are Lake, Porter, Laporte and the greater parts of Starke, Pulaski and Jasper counties.

In the southern half of the State most of the counties contain outcrops of limestone or fluviatile deposits of gravel, suitable for road improvement. In the southwestern corner there are some half dozen counties, as Posey, Vanderburgh, Warrick, Gibson, Pike and Dubois, which have hitherto imported most of their road material. Other than these, the present report will show that each county of the State contains either gravel or stone suitable in quality and sufficient in quantity for the improvement of its roads.

When we take into consideration that thousands of square miles in Illinois, Iowa, Missouri, Kansas and other states to the west are utterly devoid of either stone or gravel, we can the more readily understand that Indiana is particularly well blessed with materials for the improvement of her highways.

Gravel Deposits of the State.

By far the most widely distributed road material in the State is gravel. This occurs in greater or less quantity in every county of the drift covered area, and frequently along the streams of the driftless area. The greater part of this gravel is of glacial origin, i. e., it was brought in and was deposited on or near the spot where it now lies by a great moving mass of ice called a glacier.

(a) *Glacial Gravel Deposits.*

A careful study of the drift deposits of Indiana has proven that there were several distinct glacial invasions of the State. The great ice sheet which was first formed several times advanced, and as often, by an increase in the temperature of the region which it entered, melted and receded, its retreat or recession being each time as gradual as its advance had been.

The first invasion of Indiana by one of these glacial lobes was from the elevated districts to the east and south of Hudson's Bay. It, in time, covered a greater area of the State than any one of those which followed. When this glacier had assumed its maximum size, its southern or front edge extended across the northwestern corner of Pennsylvania and central Ohio to a point a little southeast of Cincinnati, where it crossed the Ohio River into Kentucky. Passing through Campbell, Kenton, Boone, Henry and Oldham counties, of that State, on a line nearly parallel with the Ohio River and some five to eight miles south of that stream, it recrossed and entered Clark County, Indiana, a little above Louisville, Kentucky. Turning abruptly northward, it passed through western Clark, northeastern Washington, central Jackson and eastern Brown counties, a distance of about 50 miles. The course is then westward for about 30 miles, through northern Brown and northern Monroe counties. In northwestern Monroe County it makes an abrupt turn to the south and leads through western Monroe, eastern Greene, western Martin and northwestern Dubois counties. From southwestern Dubois the course is south of west across Pike, Gibson and Posey counties to the extreme southwestern corner of the State.

Since this first or oldest glacier covered most of Illinois, the

name "Illinoian" has been given to the drift material which it brought down. The terms "older glacier" and "older drift" are sometimes also used when referring to it and its deposits. It appears that the margin of this first ice sheet is exposed only in a few counties in Indiana, in the southwestern and southeastern portions of the State, the remainder being covered by later deposits of drift. The thickness where this single sheet is exposed to view averages scarcely more than 30 feet, or less than one-fourth the estimated average for the State.

When the ice of this first glacial invasion melted away, its drift, composed of a motley mass of materials, exposed to the agencies of water, wind and frost, was left behind. What is known as the *"First Interglacial Interval"* then ensued, during which a vegetation arose on the surface of the Illinoian drift and for a long period flourished and decayed, in the manner as does the vegetation of our present surface. As a result a black mold or soil was gradually formed, which is now concealed beneath deposits of silt called "loess" in southwestern Indiana, and beneath the drift of later glacial invasions in the northern part of the State. How long this "interval" lasted no one knows, but evidently hundreds of years, as shown by the thickness of the soil mentioned and by other evidence which the geologist can take into account.

A "Second Glacial Epoch" or invasion then occurred, during which the ice brought down much thicker deposits of drift than in the first. Of it in Indiana Prof. Chamberlain has written in part as follows: "The border of the 'newer drift,' slightly ridged, may be traced diagonally across the northeastern part of Montgomery County, the center of Hendricks, the northeast corner of Morgan, the southwest portion of Johnson, striking the basin of the East White River near Edinburg. On encountering this basin the newer drift border comes in association with the remarkable fluvial phenomena of 'Collett's Glacial River.' This was one of the great avenues of discharge from the ice border, and has left its record in broad belts of gravel gathering into a great trunk stream. The edge of the newer drift sheet is interrupted and obscured by these fluvial deposits, but it seems to have formed a lobe, reaching down the basin into Jennings County, the glacial river lying on its western border. The eastern edge of the loop runs

north diagonally across Decatur County, the southeastern portion of Rush, the northwestern part of Fayette, and of Wayne, in the northern portion of which, and the southern part of Randolph, it recurves to the southeast to form the Great Miami Loop in Ohio."*

The gravel deposits of the State form a very large percentage of the morainic material or till which was dropped where it now lies by the melting of one or more of these great ice sheets or glaciers which thus invaded Indiana. In the process of retreating, each of the several great glaciers deposited its load of gravel and other material under different conditions. These deposits, according to their form or manner of distribution, are known by different names, as till or drift sheet, moraines, eskars, drumlins, etc.

Till or drift sheet is the name given to the great mass of commingled coarse and fine materials which, when the ice melted, filled up the old valleys and covered the plains to a varying depth with a broad sheet which yet occurs over all parts of the glaciated or old ice covered district, except where it has been eroded or swept away by streams. This till varies much in its composition, and in Indiana averages about 130 feet in thickness. Over the greater part of its area bores, wells and other excavations made in it show its upper portion to be made up of layers of material arranged about as follows: soil, yellow clay, blue clay, gravel. Oftentimes a layer of sand of varying thickness intervenes between the blue clay and gravel. Again the gravel lies just beneath the soil or the uppermost layer of clay. Thus the top of the gravel lies at various depths below the surface, and the bed of gravel varies greatly in thickness.

Where this drift gravel has been exposed along streams or where it lies close enough to the surface that it can be easily reached by stripping, it often affords large deposits of excellent road material. It is in many places mixed with sufficient oxide of iron, carbonate of lime or other cementing matter to cause the pebbles to adhere and pack quickly when exposed to the pressure of traffic. The pebbles composing it are largely (40 to 70 per cent. of them) rounded fragments of igneous rocks, diorite, diabase, syenite, granite, etc., derived from outcrops and exposures in British America and northern Michigan, over which the glacier moved in its

*"The Terminal Moraine of the Second Glacial Epoch," in Third Ann. Rep. U. S. Geol. Surv., 1883, 333.

journey southward. The remainder are mostly of limestone, derived from the ledges of that sedimentary rock in Michigan and northern Indiana. In many places there is too large a proportion of clay or sand mixed with the gravel to allow of its use as a road material unless it be screened.

Moraines consist of large, irregular masses of debris shoved forward by the glacier or melted out of it along its front. They are usually in the form of ridges, and mark the lines where the edges of the glaciers rested for some time and allowed the material carried by it to be dropped in quantity. These moraines contain usually much less clay and sand, and a larger proportion of gravel and boulders than the sheet-like deposits of till above mentioned. During one of the later glacial invasions of the State, the front of the ice sheet, instead of being straight, was divided into a series of large lobes, to which distinguishing names have been given by glacial geologists. At the junction of these lobes great interlobate moraines were formed. "One of these, occupying the line between the Saginaw and Erie-Maumee lobes, leads from the northeastern corner of Indiana southwestward to Cass County. These interlobate moraines are generally more prominent than those formed at the ends of the lobes. The one just referred to has a few knolls which rise nearly 200 feet above the neighboring basins, though the oscillations in level between knolls and basins are generally less than 50 feet. One of the most prominent moraines formed at the end of an ice lobe is the Valparaiso, situated north of the Kankakee Basin, in northwestern Indiana, and so called from the city of Valparaiso, located on it. It was formed by the Lake Michigan glacier at a time when that glacier extended but little beyond the limit of the shore of Lake Michigan. Another prominent moraine, known as the Maxinkuckee, leads southward from Michigan past South Bend to Lake Maxinkuckee, and thence eastward to join the great interlobate moraine formed between the Saginaw and Erie lobes. It was formed by the Saginaw ice lobe at the time it first became clearly differentiated from the Erie lobe."*

These large interlobate moraines are the sources, either primarily or secondarily through the action of streams, of much of the gravel

*Leverett.—Water Supply and Irrigation Papers, U. S. Geol. Surv. No. 21. 1899, p. 11.

suitable for road materials in the counties of the northern third of the State. More commonly, in the other drift covered counties, the moraines are in the form of slight ridges which may be covered with soil but show here and there projecting boulders. In general it may be said that such moraines afford better sites for gravel pits from which road materials are to be obtained than the till, since, as above mentioned, they are usually much freer from sand and clay.

Eskars are narrow, elongated ridges of rudely stratified coarse and fine gravel, sand and *water-worn* stones, which almost always extend in the direction of the ice movement. They occur usually over lands lower than the moraines, and are supposed to have been formed in the caves or waterways beneath the ice, through which the ancient subglacial streams found their way. They were doubtless formed in part, also, by the gushing streams from the ends of rapidly melting glaciers. They often occur in connection with moraines and contain large and useful deposits of gravel, and also large numbers of boulders, which might be crushed and used for road material. Examples of eskars will be noted by several of the assistants in the subsequent papers descriptive of the local deposits in the different counties.

Drumlins are commonly more or less oblong, smooth featured hills, having their longer diameter in the direction of the movement of the glacier. They were probably formed under the ice sheet, and not far from its melting margin. They often contain a nucleal or central mass of stratified gravel and sand, but are less liable than eskars to afford good road material. But few of them occur in the glaciated portion of this State.

In searching for gravel in the various glacial deposits above mentioned one can not put much dependence in the character of the soil. The presence of any distinct uprise or ridge in the surface affords some reason to expect that a deposit of gravel lies beneath. By following along streams one can often find where they have cut through the overlying soil, clay or sand and exposed the gravel. Groundhogs or other burrowing animals often throw out sufficient gravel to denote its presence. The best method of exploration is by means of a steel rod or drill, which can be forced through gravel but not through clay. The ordinary post hole auger may be made to serve its purpose. Where useful material is found it may be

worked in open pits, preferably by the use of the steam shovel; or if, as is the case in some parts of the drift, the superficial coating is heavy, it may be necessary to resort to the ordinary methods of the miner, but even in these cases we may expect, considering the needs of the country, that comparatively cheap road-building materials may be obtained. In general, however, it will probably be better to enter the deposit at the base of a slope at the level of a stream bed, so that water may be had for washing, if that process is to be used, and natural drainage obtained.

(*b*) *Fluvial Gravel Deposits.*

During the thousands of years which have elapsed since the glacial gravel was dropped in Indiana by the melting ice, much of it has been washed hither and thither by streams. In the valleys of these streams, both large and small, are now to be found some of the largest and most available deposits. Some of these have been washed out, carried onward and redeposited perhaps a score of times.

Each stream in the State is continually changing its course. Those which issued from the foot of the melting ice front were many of them much greater in size than those of the present day. They were in many places exceedingly swift and torrential in their flow. Under the abundant supply of water, the width of the flood grounds or valleys in many instances were miles in extent. Over these flooded areas much gravel and sand was carried, assorted and deposited by the flowing water. As the stream gradually diminished in size it was often, by dams of ice or other obstruction, changed from side to side of its former valley. Whenever a change was made it eroded some of the old gravel deposits and carried them down to new locations. A close examination of any of the larger streams in the drift covered area of the State will, therefore, show: (1) An old stream bed far deeper and broader than that occupied by the present stream. (2) That this deep and broad stream bed is filled up, often scores of feet in depth, by the old stream deposit. (3) Into this old deposit the shrunken stream of the present is again cutting its way, and annually changing to some extent its course. This cutting into the old deposit produces bluffs and terraces on each side.

Figure 23 is an ideal section across a stream bed in the drift region of the State, in which *b b* is the old stream bed, scooped out by the moving glacier or by the high water which followed; the dotted line represents the highest level to which the old stream deposit accumulated, and the shaded portion that part of such deposit

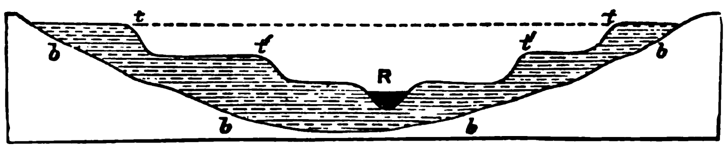

Fig. 23: Ideal section across a river-bed in drift region: *b b b*, old river-bed; *R*, the present river; *t t*, upper or older terraces; *t' t'*, lower terraces.

which still remains. The upper terraces *t t* are of course the oldest, the lower ones being formed as the shrinking stream cut deeper and deeper. The present flood plain lies between *t'* and *t'*. It is in the terraces and flood plains of the present streams that much of the available gravel of many of the drift covered counties is to be found. Especially are the terraces along the Wabash, the Mississinewa and the upper course of the West Fork of White River rich in these deposits.

Every stream in the State has gravel bars along its flood plain and beneath the shallow water of its bed. In a number of places sand and gravel pumps are at work sucking up the materials and assorting them by screens. They are then utilized for building purposes, concrete and road materials. Several barges with pumps attached are at work in White River near Indianapolis. In general everything which will not pass through a two-inch screen is cast aside. The materials which will not pass through a seven-eighths-inch screen is termed *gravel* and is used for concrete, roads, etc. That which passes through a seven-eighths-inch but not through a three-eighths is called *pebble,* and is mainly used for roofing purposes. That which passes through a No. 4, or three-eighths-inch, screen is sand, used for plaster, concrete sidewalks, etc.

Much of the stream gravel hitherto used on the roads of the State has been unscreened and was mixed with far too great a percentage of sand. In some places the gravel was too clean, i. e., did not contain enough cementing material to cause it to pack sufficiently on the roads. Due to the assorting power of water, the coarser gravel is always found in the upper end of the bars.

In some instances a stream has so changed its course that, in places, it now flows entirely to one side of its old bed and alongside a bluff of glacial gravel which has not been disturbed since it was dropped by the ice. These bluff exposures, where not too heavily covered, afford rich deposits of road material. From them the stream erodes great quantities of gravel during each freshet and bears it down to form new bars.

(c) *Gravels of Disintegration.*

In the unglaciated portion of southern Indiana the stream or "creek gravels," as they are there called, are mostly derived from the oxidized and partly decayed country rock, and may be termed "gravels of disintegration." In at least two distinct geological areas these creek gravels are much used as road materials, and experience has proven that they pack easily and are durable under the traffic of the main country highways.

Knobstone "Creek Gravels."

One of these areas is that of the Knobstone. This formation comprises the surface or country rock of a strip of territory three to 38 miles in width, extending from the Ohio River southwest of New Albany in a west of north direction to a point a few miles south of Rensselaer, Jasper County. Over much of the northern part of this area the Knobstone is in most places covered by a heavy mantle of glacial debris, its outcrops being exposed only along the stream valleys. Exposures of the Knobstone are known to occur in the following counties: Harrison, Floyd, Clark, Washington, Scott, Jackson, Lawrence, Monroe, Brown, Bartholomew, Johnson, Morgan, Owen, Putnam, Hendricks, Marion, Boone, Montgomery, Clinton, Tippecanoe, Fountain, Warren, White, Benton and Jasper. In the first ten mentioned counties the Knobstone almost everywhere comes to or very near the surface, as the cover of drift is either wanting or very thin. The rocks of the Knobstone proper consist of blue-gray shales, shaly sandstone, sandstone and rarely a little limestone. They are everywhere too soft and brittle to be utilized as road material. However, they contain, and abundantly in places, numerous nodules or concretions of

siderite or iron carbonate, many of them of considerable size. These are usually made up of concentric or successive layers, like those of an onion. As the soft shales weather away, especially in winter and spring, by the action of alternate freezing and thawing, these nodules are left exposed on the slopes. They are insoluble, but in time they break up or flake into small quadrangular pieces an inch or two square on the broad surface and a fraction of an inch in thickness. Sometimes the surface of the slope is so thickly covered with these dark brown fragments of disintegrating nodules of iron that one can not see the top of the shale beneath. In time these are washed down into the numerous little swales or gullies which are everywhere to be found along the slopes of exposed shale, and from these they find their way down to the beds of the larger creeks and streams which drain the region. Mixed with these fragments of iron nodules are drift pebbles, the outwash of the glacial regions to the north, and also angular pieces of limestone from the formations bordering the Knobstone.

From this mixture of so-called "creek gravels" many miles of improved roads have been constructed in Clark, Floyd, Scott, Washington, Jackson and Brown counties. The carbonate of iron present acts as a cement to bind the other materials together. For this reason the gravel packs very quickly and compactly into a smooth and durable road. The surface of the road made from this gravel is reddish brown in color. It does not reflect the sunlight on a hot summer day like the gray or whitish roads made of limestone or drift gravel, and is, therefore, more agreeable to travel. Throughout the Knobstone area south of Morgan County these ironstone gravels offer a cheap and seemingly durable material, sufficient in quantity to improve all the roads of the region.

Creek Gravels of the Harrodsburgh Group.

Overlying the Knobstone formation and underlying the oölitic limestone to the west is the Harrodsburgh Group, which consists chiefly of limestones containing many remains of crinoids. Intermingled with the limestone layers are thin layers of shale and small quantities of flint. In the limestone, and less commonly in the shaly layers, quartz geodes occur, often in great numbers. These are often called "muttonheads," and range in size from a pea up

to two feet in diameter. They consist of an outer crust of crystalline quartz or quartz and chalcedony, which is lined or entirely filled with crystals. These crystals are most commonly quartz or calcite, or the two together, frequently quartz lining the shell and the central space filled with calcite. Several other minerals often occur in smaller quantities. "These gėodes are supposed to occupy the center of sponges that existed in the seas when the Keokuk (Harrodsburgh) limestone was laid down. These sponges were hollowed out by siliceous solutions and then lined with crystals by deposition from the same or some other mineral solution."*

So abundant are these geodes that in places the gravel bars on the creeks of the Harrodsburgh area are largely composed of them or of their fragments. Mixed with them to form the remainder of the gravel are pieces of chert and small, more or less angular pieces of the partially decayed limestone; also many fragments of crinoids and other fossils of the limestone. The crust of the geodes being very hard and the limestone furnishing a good cementing substance, these gravel bars provide a road material which is durable and packs smoothly and compactly. A number of the country roads of eastern Lawrence County have been improved with this gravel, and have proven durable under the traffic of the region. The gravel is abundant along the streams which drain the Harrodsburgh area of the State, and is well worthy the attention of road contractors.

The Mitchell limestone which overlies the Bedford oölitic stone to the west, in many places contains in its upper courses numerous flint nodules which, together with weathered fragments of the limestone, are often washed down into the creek beds of the Mitchell area, where they form gravel bars. These have been drawn upon in some places, notably along Lost River and its tributaries in northeastern Orange and northwestern Washington counties, to furnish road material. Some of the roads about Orleans constructed of this creek gravel are the equal of any gravel roads which have come to the writer's notice in the State. While the amount of the material is not large, it merits careful attention, as it packs readily, wears smooth and is seemingly above the average in durability.

*Dana, Man. of Geol., 4th Ed., p. 97.

Boulder Deposits of Indiana.

In many of the deeper drift covered counties of northern Indiana boulders, or "niggerheads," are present in quantity sufficient to be used as road material. They are usually accompanied by gravel which, on account of its abundance and availability, has been used in preference to the boulders on such roads as have been improved. The bowlders are mostly of igneous rocks, such as diorite, diabase, granite, gneiss, syenite, etc. They are, therefore, better adapted for a road material than many of the limestones of southern Indiana. They are hard and tough, and when properly broken to small sizes and rolled thoroughly will cement and consolidate into a smooth, hard crust which is impervious to water, and the broken particles are so heavy that they are not readily blown or washed away.

The boulders of Indiana are all of glacial origin and came from northern Michigan or British America, where such rocks are abundant in dikes or ledges. They range in size from a few ounces up to 20 or more tons. Along the moraines of some of the great glacial lobes which invaded northern Indiana they are so common that fences are built of them, and in cultivated fields they are gradually worked to the top in such numbers that they have to be removed each year. Especially is this true in portions of Steuben, Lagrange, Elkhart, Kosciusko, Noble, Whitley, Marshall, Fulton and Cass counties. The largest of these boulders can be easily broken by some explosive into sizes suitable to enter a crusher.

As to the construction of macadam roads from such boulders, Mr. B. W. Potter has written as follows:* "In the construction of a macadam road in any given locality the question of economy generally compels us to use a material found near at hand, and where a local quarry does not exist field stone and stone gathered from the beds of rivers and small streams may often be made to serve every purpose. Many of the stones and boulders thus obtained are of trap rock, and in general it may be said that all hard field and river stones, if broken to a proper size, will make fairly good and sometimes very excellent road metal. No elaborate test is required to determine the hardness of any given specimen. After a brief experience a judicious person with a light sledge ham-

*"The Road and the Roadside," 1886, p. 72.

mer can, by striking the stones which offer themselves to use on the surface of the field and in the walls, readily determine the state of the masses. If they ring sharply to the blow they may be judged sufficiently sound. If, however, they pulverize under the successive strokes, and when broken show evident traces of decay, as by iron stains penetrating the mass, they may be condemned as a source of supply. Field and river stones offer an additional advantage in that they are quickly handled, are generally of convenient size, and are more readily broken either by hand or by machine than most varieties of rock which are quarried in the usual way."

Limestones of Indiana which may be Utilized for Macadam Purposes.

The sedimentary rocks which comprise the surface of Indiana are limestones, sandstones and shales. No igneous or metamorphic rocks occur in the State except in the form of boulders above mentioned. Of the three groups of sedimentary rocks the limestones are by far the more widely distributed. Those of at least eight geological formations are being or have been used for macadam purposes, though all are not well suited for road making. Each of the eight will in this connection be treated briefly as to its distribution, physical properties and general fitness for road material.

(a) *The Ordovician Limestones.*

The Ordovician limestones and their accompanying shales comprise the oldest rocks of Indiana, and come to the surface only in its southeastern corner, where they comprise the surface of all or part of the following counties: Wayne, Union, Fayette, Franklin, Dearborn, Ripley, Ohio, Switzerland and Jefferson. They are also exposed along various streams in southern Decatur and eastern Jennings counties in areas otherwise occupied by the Silurian. Along the Ohio River they may be traced as far southwest as Charlestown Landing, in Clark County. While the drift covers all of this area, it is everywhere quite thin, and in the valleys and the beds of the streams the surface rocks are exposed.

The limestones of the Ordovician area occur in beds ranging up to 40 or more feet in thickness. Each bed is made up of thin layers, usually not exceeding six inches and often less than three inches in thickness. The layers are often dark blue in color and

very hard. Many show their organic origin by the presence of fossils. Some are distinctly crinoidal. Others consist chiefly of brachiopoda or bryozoa cemented together by a mass of calcareous sediment.

These limestones have been separated by Foerste and other writers into several different groups, to each of which a distinct name has been given. The Bellevue bed of the Lorraine formation forms the surface in many parts of Dearborn, Ohio and Switzerland counties. It has a thickness ranging between 20 and 25 feet, and is usually a coarse rubble limestone, but at some localities the lower part of the bed consists of dark, bluish gray, coarse grained, massive limestone, the middle of rubble limestone and the upper part chiefly of clay. The stone from it and allied beds has in recent years been used for the improvement of roads in the three counties above mentioned. Samples from near Dillsboro were tested in the laboratory of the Office of Public Roads at Washington, D. C., the results of the test showing as follows:

*Results of Test of Ordovician Limestone from near Dillsboro, Dearborn County, Indiana.**

Specific gravity.................	2.7	French coefficient of wear.	8.3
Weight per cu. ft..........(lbs.)	168.4	Hardness.................	9.8
Water absorbed per cu. ft..(lbs.)	.78	Toughness................	7
Per cent. of wear..............	4.8	Cementing value—Dry....	67
		Wet....	100

(b) *The Niagara Limestones.*

These limestones comprise the principal formation representing the Upper Silurian Period in Indiana. By Foerste and others† this formation has been subdivided into five different horizons, which from east to west, or in ascending order, are as follows: Clinton limestone, Osgood clay and limestone, Laurel limestone, Waldron clay, Louisville limestone. In the southern part of the State, where the cover of drift is thin or wanting, these subdivisions can be easily separated one from another. In the northern part, where the exposures are few, their differentiation is much more difficult. In this connection, therefore, we will treat them under the one head, the Niagara, referring only casually to the more local names given by Foerste.

*For standard of comparison see p. 79.

†See 28th Rep. of this Dept., p. 27 *et seq.*

The Niagara limestone forms the surface rocks over a wide area of the eastern and northern portions of the State and also over an irregular, narrowing strip 30 miles to one in width, extending southward from Newcastle, Henry County, through portions of Wayne, Rush, Fayette, Franklin, Decatur, Ripley, Jennings, Jefferson and Clark counties to the Ohio River near Jeffersonville. It is also exposed along the valleys of a number of streams in eastern Shelby and Bartholomew counties. Through this narrow southern strip the rock is close to the surface, but in the larger area north of Newcastle it is nearly everywhere covered with deep drift. However, in the valley of the Whitewater and its tributaries in northern Wayne County, at Portland, Jay County, and along the Wabash River in the vicinity of Bluffton, Huntington, Wabash and Logansport it comes to the surface, as also in isolated areas near Delphi, Monon and Kentland.

The Niagara limestone ranges from nearly white through buff to blue in color, and from a hard, subcrystalline stone to a soft, shaly one in structure. In Wayne, Fayette, Franklin, Rush, Decatur, Jennings and Ripley counties of its southern area, and in Wabash of its northern it is in places especially hard and compact, of even texture and color, and often occurs in thin, easily separated layers, usually from three to 12 inches thick, which are largely quarried for flagging, curbing and similar uses. These form the so-called Laurel limestone of Foerste. Southward, in Jefferson County, the limestone deteriorates rapidly in quality. The rock is less pure, becomes softer, more argillaceous and does not form slabs of equally large dimensions. In Clark County the rock becomes still softer and more argillaceous. Its color changes to brown, and usually the rock does not withstand weathering. At some localities a few of the layers furnish a good building rock, while the greater part of the section is of inferior quality. Chert frequently is present, especially in the middle part of the section, five or more feet above the base of the Laurel. However, at many localities the layers which are free from chert are readily accessible and are quarried with profit.

The chemical composition of the Niagara limestone varies greatly. In southern Indiana it usually contains only from six to ten per cent. of magnesium carbonate, but the outcrops along the Wabash River and in Adams, Jay and Randolph counties are a true

Plate II.

Northeast part of Wabash Dome; strata dipping northeast.

Southwest part of Wabash Dome; strata dipping southwest.

ILLUSTRATING THE TILTED NATURE OF THE NIAGARA LIMESTONE AT WABASH, WABASH COUNTY.

dolomite containing 40 per cent. or more of this compound. This is especially true of certain outcrops in the vicinity of Huntington, Wabash and Delphi, where the Niagara stone seems to have passed through an upheaval, the strata being tilted in various directions, sometimes at an angle of 45 degrees or more. Near Delphi, Monon and Kentland, Newton County, the Niagara comes to the surface in isolated islands in which the layers show this same tilted condition.

The following table shows the variability of the Indiana Niagara limestone in chemical composition:

Analyses of Indiana Niagara Limestone.

Source of Sample.	Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$).	Ferric Oxide and Alumina ($Fe_2O_3+Al_2O_3$).	Insoluble Residue (Silica, etc.).	Sulphuric Anhydride.	Total.	Authority.
Consolidated Lime Company, Huntington	53.22	44.96	.23	.59	.11	99.11	R. E. Lyons.
Harley Bros. Quarry, Delphi, Carroll Co.	54.53	43.92	.51	.19	.18	99.33	R. E. Lyons.
Greensburg Stone Company, St. Paul, Decatur Co.	74.02	10.35	6.20	5.90	.90	97.37	E. T. Cox.
Scanlan's Quarry, Flat Rock Creek, Decatur Co.	83.00	6.3	2.50	5.30	1.00	98.10	E. T. Cox.

The Niagara limestone has been used more extensively for road material than any other limestone in the State. This is on account of its wide distribution rather than for any special fitness which it possesses. Numerous tests show it to rank below the Mitchell limestone in resistance to wear, though its cementing qualities are better. Large and permanent crushing plants which prepare the stone for macadam use are in operation at a number of places throughout its area.*

At numerous places quarries have also been opened in the Niagara for crushing with portable crushers for local use on the roads. Near Kentland, Newton County, one of these crushers has just been shut down after operating four years, during which time 100,000 cubic yards of stone was crushed and used in building 62 miles of macadamized roads in two townships of that county.

*For a list of these see table at end of section.

As is natural throughout such a wide area as that covered by the Niagara, there is much variation in the quality of the stone for macadam purposes. In some places the tests show the rock to be above the average for resistance to wear and in cementing value, while in others, notably at several points near the Ohio-Indiana line in Adâms, Jay and Randolph counties, the exposed stone is soft, friable and rather coarse grained, running below the average in the tests made.

The following are the results of tests of this stone from seven widely separated counties of its northern area, made in the Road Testing Laboratory at Washington, D. C. The *average* of 192 samples of limestone tested for road purposes is also given for comparison. The results of the tests of the samples of Niagara submitted from Indiana, 31 in number, will be found on subsequent pages in connection with descriptions of the local deposits under the respective county headings.

Results of Physical Tests of Niagara Limestone from Seven Different Localities in Northern Indiana.

Origin of Sample.	Specific Gravity.	Weight per Cubic Foot. Pounds.	Water Absorbed per Cubic Foot. Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry and Wet.
1. **Average of 192 samples**	2.7	165.7	1.39	5.7	8.7	3.4	11	32 59
2. **Kentland, Newton Co**	2.7	168.4	.33	4.1	9.7	12	12	19 33
3. **Wabash, Wabash Co. (Bridges Sons)**	2.8	171.5	.43	3.3	12.1	11.5	9	17 21
4. **Rockford, Wells Co**	2.7	165.3	3.29	5.1	7.8	13	14	22 37
5. **Pleasant Mills, Adams Co.**	2.56	159	3.56	10.23	3.91	......	......	10 22
6. **Ridgeville, Randolph Co**	2.65	165.3	.77	7.2	5.6	7	6	11 19
7. **Alexandria, Madison Co**	2.7	165.3	1.41	4.3	9.3	1.8	7	26 28
8. **Noblesville, Hamilton Co**	2.8	171.5	1.08	4.9	8.1	13.8	9	15 26

(c) *The Devonian Limestones.*

The Devonian limestones represent in part the Devonian rocks of Indiana. By Kindle and others they have been divided into three beds, which, in ascending order, are the Jeffersonville Lime-

stone, the Silver Creek Hydraulic Limestone and the Sellersburg Limestone.

The northern part of the Devonian area of Indiana is heavily covered with glacial drift, and it is only in the southern part of the State that the exposures of the above limestone are sufficient in quantity to be used extensively as road material. The principal exposures are in Shelby, Bartholomew, Jennings, Jackson, Scott, Jefferson and Clark counties, where for the most part the glacial drift is thin or absent, and where the area is more deeply dissected by the streams flowing into the Ohio River. As one goes northward from that river the valleys become shallower and the glacial drift deposit heavier, and hence the underlying rocks show in fewer exposures. North from Shelby County the only exposures of the Devonian rocks through the drift are a small area in the vicinity of Pendleton and several small areas in the vicinity of the Wabash River.

The Jeffersonville limestone is a gray or bluish gray crystalline, fossiliferous limestone, occurring both massive and in thinly stratified layers. At the Falls of the Ohio it has a thickness of about 20 feet, and from it have been obtained numerous fine examples of coral fossils. Northward it thickens rapidly, ranging up to 50 and 60 feet in the neighborhood of North Vernon. It has been used to some extent in Clark, Jefferson, Jennings and Ripley counties as a road metal.

The Silver Creek hydraulic limestone lies between the underlying Jeffersonville and the overlying Sellersburg limestones. It is a fine-grained, clayey magnesian limestone five to 16 feet in thickness, but too soft for macadam purposes. From its numerous exposures has been made for more than 50 years a high grade of hydraulic or natural rock cement.

The Sellersburg limestone lies next above the Silver Creek bed and just below the New Albany black shale. It is a white to gray crystalline, crinoidal limestone which has been used locally for building stone and quite extensively for road metal. Its exposures occur from the Ohio Falls as far north as Decatur and Shelby counties, the beds running usually from five to 12 feet in thickness and offering a good and easily available macadam stone.

In the northern part of the Devonian area the Sellersburg and Jeffersonville limestones above mentioned are exposed along the

Wabash River and some of its tributaries in Miami and Carroll counties, and on the Tippecanoe River north and south of Monticello, White County. The stone at all of these exposures is hard enough for macadam purposes, and in a region where outcrops of stone are few offer a supply of road material which will be found better than much of the gravel now being utilized in the counties mentioned for that purpose. The following are the results of tests of Devonian stone from four different counties in the southern part of the State. The tests were made in the Road Testing Laboratory at Washington, D. C., and the *average* of 192 samples of limestone tested for road purposes is also given for comparison:

Results of Physical Tests of Devonian Limestone from Four Different Counties in Southern Indiana.*

Origin of Sample.	Specific Gravity.	Weight per Cubic Foot. Pounds.	Water Absorbed per Cubic Foot. Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry and Wet.
1. Average of 192 samples..........	2.7	165.7	1.39	5.7	8.7	3.4	11	{ 32 59
2. Hope, Bartholomew Co..........	2.7	171.5	1.71	5.9	6.7	—1	5	{ 20 41
3. Hayden, Jennings Co............	2.7	168.4	.93	3.2	12.6	8.5	9	{ 49 97
4. Deputy, Jefferson Co	2.7	168.4	.43	4.7	8.5	—0.3	7	{ 53 81
5. Charlestown, Clark Co	2.6	162.2	1.41	5.6	7.1	3.5	8	{ 17 52

*For explanation of these tests see pp. 64-79.

(*d*) *The Harrodsburgh Limestone.*

This limestone has already been mentioned as being the source of one of the "creek gravels" used for road material in southern Indiana. It is the lowermost of the three principal limestones of the Mississippian or Lower Carboniferous Period, and lies between the Knobstone to the east and the Bedford Oölitic limestone to the west. It is usually quite sharply separated lithologically from the overlying oölitic stone, but in many places grades insensibly into the underlying Knobstone shales.

The Harrodsburgh limestone outcrops along a belt extending from the Wabash River in Warren and Tippecanoe counties in an east of south direction to the Ohio River and beyond into Ken-

tucky. The outcrop varies in width from a few feet to several miles. In the central part of its area the Harrodsburgh limestone and shales vary from 60 to 90 feet in thickness. It thins out somewhat to the north, and near its northern limits it appears only in isolated patches. Its principal exposures are in Putnam, Owen, Monroe, Lawrence, Washington and Floyd counties, though outcrops occur in limited areas in the southwestern portions of Montgomery, Morgan and Jackson counties.

The Harrodsburgh group consists chiefly of limestones which frequently contain a great many crinoid remains. Intermingled with the limestone layers are thin layers of shale and small quantities of chert. In the limestone, and less commonly in the shaly layers, quartz geodes occur in great numbers. These appear to be more abundant in the lower than in the upper layers, and occasionally occur in the underlying Knobstone layers. The limestone is only of medium hardness, and in places coarsely crystalline, especially the crinoidal layers. The crinoid stems are always coarsely crystalline calcite, and the ground mass in which they are imbedded is crystalline in part, but consists largely of mud deposits.

The Harrodsburgh limestone has been used in building roads at many points over the area of its outcrop, especially in Putnam, Owen, Monroe and Lawrence counties. It has also been extensively quarried near Salem for railway ballast. On account of its greater hardness it is a better road material than the overlying oölitic stone, but is softer, less tough and has poorer cementing properties than the Mitchell limestone, which is usually found abundantly in close proximity to the west. The Mitchell is, therefore, used or should be used in preference when it can be obtained at a reasonable cost.

(*e*) *The Bedford Oölitic Limestone.*

This is the best known limestone in the State, being the formation so extensively quarried for building and ornamental purposes. It forms a portion of the surface rocks in a narrow, irregular strip from two to 14 miles in width, extending a distance of 142 miles from near Parkersburg, Montgomery County, to the Ohio River. Its outcrops occur in Putnam, Owen, Monroe, Lawrence, Washington, Floyd and Harrison counties. Numerous quarries have been opened throughout this area for building stone.

The Bedford oölitic stone ranges from a creamy white to a dark drab in color. It is very uniform in grain and quite soft when first quarried. It occurs in large masses, from which blocks of any required size can be obtained. On account of its softness it can be cut from the quarry with greater ease than almost any other rock, and can be readily sawed or carved into any desired form. Under the microscope it is seen to be made up of the globular shells of minute one-celled animals. These are composed of carbonate of lime and are cemented together by the same material, so that the rock is a very pure limestone.

From a number of analyses of the Bedford stone made by Dr. Noyes for the Twenty-first (1896) report of this Department the following are taken to show its composition:

Analyses of Bedford Oölitic Limestone from Southern Indiana.

Source of Sample.	Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$).	Ferric Oxide (Fe_2O_3).	Insoluble Residue (Silica, etc.).	Total.
Bedford, Indiana, Stone Quarry, Lawrence County.	98.27	.84	.15	.64	99.90
Hunter Bros. Quarry, Monroe County	98.11	.92	.16	.86	100.05
Romona Oölitic Stone Company, Owen County	97.90	.65	.18	1.26	99.99
Twin Creek Stone Company, Washington County	98.16	.97	.15	.76	100.04

The Bedford stone loses its massive structure just north of Romona, Owen County, and above this point becomes thin-bedded or even shaly on some of its exposures. It has been quarried quite extensively for road metal near Greencastle, Putnam County, and for local use on the roads at several other points in the southern and southeastern parts of that county. It has also been used to a small extent for road material in Owen, Monroe and Lawrence counties. On account of its softness it soon grinds up when exposed to heavy traffic, and roads made from it are far less durable than those from either the Mitchell or Harrodsburgh limestones. In Monroe County a creek gravel has been used as a top dressing on several of the roads built of the oölitic stone, and has added materially to their durability.

(f) *The Mitchell Limestone.*

Overlying the Bedford oölitic stone to the west is a heavy bed of compact limestone and chert, intercalated in places with thin layers of limy shales. This is the Mitchell limestone. Its exposures occur over an irregular area three to 25 miles in width, extending through the central part of southern Indiana from the Ohio River in Harrison County north and northwestward to the southwestern corner of Montgomery County, where they disappear beneath the drift. Outcrops occur in each of the following counties: Harrison, Crawford, Floyd, Washington, Orange, Martin, Lawrence, Monroe, Greene, Owen, Morgan, Putnam, Parke and Montgomery. In the middle portion of its area the Mitchell stone ranges from 150 to 250 feet in thickness, thinning out towards the north and thickening to the south, as at Corydon, Harrison County, where it is 350 to 400 feet thick.

The Mitchell limestone varies much in structural character and appearance. In most places it is a fine-grained crystalline or subcrystalline stone which is quite hard. In the southern part of its area there are found in a number of localities, near the top of the Mitchell and between the beds of grayish stone, layers having an oölitic structure, nearly pure white in color and much softer than the gray. In a great many places throughout the area a good quality of flagstone and heavy building stone could be obtained from the bold outcropping ledges of the limestone. The chert occurs in varying quantities at different horizons, sometimes a few scattered nodules which may increase in size and number until they replace a greater part of the limestone. On the weathered exposures the lime carbonate is leached out and the chert fragments left in large numbers through the residual limestone clay.

Both the oölite above mentioned and the more common gray, compact Mitchell limestone comprise the purest forms of carbonate of lime found in the State. The following table of analyses shows the composition of the Mitchell limestone from four widely separated localities:

Analyses of Mitchell Limestone from Southern Indiana.

Source of Sample.	Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$).	Ferric Oxide and Alumina ($Fe_2O_3+Al_2O_3$).	Insoluble Residue (Silica, etc.).	Total.	Authority.
Oölite from Bichel Quarry, Milltown, Ind..................................	98.91	.63	.15	.48	100.17	W. A. Noyes.
Gray stone from Mitchell Lime Quarry, Mitchell, Ind..............	96.65	1.20	.27	1.57	99.69	—— ——
Gray stone from South of Harrodsburgh, Ind............................	97.64	....	.32	.82	98.74	T. W. Smith.
Gray stone from land of J. B. Lyne, Monroe County......................	99.04	....	.09	.80	99.92	T. W. Smith.

The Mitchell limestone is quarried in large quantities and used for road metal, wagon roads or railways, for flagstone, for paving and curbing, for burning to quicklime and for building stone. It is one of the best road metal stones in the State of Indiana. It wears and packs better than the more granular oölitic stone or the more crystalline Harrodsburgh. It compares favorably with the Niagara limestone of Silurian age in this respect, but is harder and generally superior, since the Niagara in many places has thin layers of intercalary shale which, if not separated in the quarrying, will quickly form mud on the roads.

The Mitchell limestone has been used quite extensively, especially during the last few years, in macadamizing the roads in the area where it occurs. Many small quarries have been opened from which the stone has been obtained for local use. A number of large railway quarries, where the stone is taken out extensively for railway ballast or road material, are also scattered throughout its area.* Each of these quarries is capable of turning out from ten to 30 carloads of crushed limestone per day.

Tests of numerous samples of Mitchell limestone from different parts of its area have been made for this report at the laboratory of the Office of Public Roads, Washington, D. C., and all have shown it above the average in resistance to wear for limestone, with fair cementing value, thus proving its general fitness for highway and country road traffic.

*For a list of these see table at end of section.

From among the tests made of the Mitchell limestone the following from five widely separated counties are given in this connection, together with the *average* of 192 limestones tested as a standard for comparison. The others will be found in proper sequence in connection with the descriptions of the deposits from which the samples were taken:

Results of Tests of Mitchell Limestone from Five Different Counties of Its Area in Indiana.

Origin of Sample.	Specific Gravity.	Weight per Cubic Foot. Pounds.	Water Absorbed per Cubic Foot. Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry and Wet.
1. Average of 192 samples...........	2.7	165.7	1.39	5.7	8.7	3.4	11	32 59
2. Greencastle, Putnam Co. (J. D. Torr)...........................	2.69	168.4	.79	3.87	10.34	14	11	8 24
3. Spencer, Owen Co	2.68	168.4	.88	3.68	10.87	6.3	10	8 21
4. Bloomington, Monroe Co........	2.6	165.3	1.7	3	13.4	9.3	13	30 41
5. Williams, Lawrence Co..........	2.7	168	.7	4.1	9.7	12	8	34 141
6. Marengo, Crawford Co	2.65	165	1.61	3.7	10.8	8.9	9	16 53

(*g*) *The Huron Limestones.*

Three beds of limestone and two alternating beds of sandstone, with smaller amounts of shale, and one or two seams of coal whose maximum thickness is four inches, comprise what is termed the Huron group of rocks in southwestern Indiana. This group of rocks lies between the top of the Mitchell limestone to the east and the bottom of the Mansfield sandstone to the west. It forms the topmost series of the Lower Carboniferous Period in Indiana, and its exposures comprise the surface rocks of a very irregular area extending from the southwestern corner of Montgomery County, a little east of south to the Ohio River. Outcrops occur in Montgomery, Putnam, Clay, Owen, Greene, Monroe, Lawrence, Martin, Orange, Harrison, Crawford, Dubois and Perry counties. "The area covered by the outcropping Huron group is characteristically hilly and broken. It forms a belt of rather conspicuous hills bordering on the west the broad, rolling, rather flat area of the out-

cropping Mitchell limestone. In places the hills are low and rounded, but are generally quite steep, with rock cliffs and talus slopes. Through western Lawrence, Monroe and Owen counties and in parts of Putnam these hills, composed of the Huron sandstones, shales and limestones, form a quite prominent feature of the landscape as one approaches them from the east over the rolling plain surface of the Mitchell limestone."*

In Orange County, where the Huron group is perhaps most typically developed, it is represented by a lower limestone, a lower sandstone, a middle limestone, an upper sandstone and an upper limestone. Some of the upper sandstone layers are used for coarse whetstones, but the greater part of the whetstones and grindstones of that county are derived from the overlying Mansfield sandstone of the Carboniferous Period.

The lower Huron limestone is a compact, smooth-grained, ash-gray to blue limestone, which runs five to eight feet in thickness. In structure it is a close, fine-textured, non-crystalline stone, breaking with a subconchoidal fracture. This structure renders it well fitted for macadam stone, for which purpose it has been used locally in a number of places.

The middle Huron limestone is usually a close-textured, semi-crystalline, grey fossiliferous limestone, which varies in thickness from five to 30 feet, averaging about 16 feet. It also has been recently used for road material in Orange, Martin and Greene counties.

The upper limestone averages about 15 feet in thickness, is more crystalline in structure, varies from dark to light gray in color and contains many crinoid stems and remains of bryozoa. It takes a fine polish and resembles marble when so treated, but does not hold the polish when exposed to the atmosphere. On account of its crystalline structure it is not so well suited for road material as the finer grained, harder rocks of the middle and lower beds. It, however, is far better than any sandstone for road purposes, though sandstone has been used in some localities where the upper limestone was available.

The following are the results of tests of two samples of the middle Huron limestone taken from different counties. The tests were

*Hopkins, 28th Rep. Ind. Dept. Geol., p. 66.

made at Washington, D. C., and the *average* of 192 limestone tests is given for comparison:

Results of Tests of Huron Limestone from Two Localities in Southern Indiana.

Origin of Sample.	Specific Gravity.	Weight per Cubic Foot. Pounds.	Water Absorbed per Cubic Foot. Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry and Wet.
1. Average of 192 samples..........	2.7	165.7	1.39	5.7	8.7	3.4	11	{ 32 59
2. Land of Geo. Cox, 4 miles N. E. of Bloomfield, Greene Co......	2.7	168.4	1.15	3	13,2	13	10	{ 21 66
3. Land of Jno. Scott, near Shoals, Martin Co......................	2 6	162.3	2.00	3.2	12.4	8.5	9	{ 18 67

(*h*) *The Carboniferous Limestones.*

The rocks of the Carboniferous Period cover all or part of 22 counties in western and southwestern Indiana. For the most part they are shales, sandstones, fire-clays and veins of coal, but associated with these are several beds of limestone. These form but a small part of the strata, since they seldom exceed four to five feet in thickness, but they are often persistent over large areas. Since a number of the counties comprising the southwestern part of the Carboniferous or coal-bearing area are lacking in gravel, these limestones furnish the only available source of road-making material unless the shales, which occur abundantly, are utilized for paving brick.

The Coal Measure limestones are generally very impure, sometimes sandy, sometimes shaly, and are often dark colored or black from the amount of bituminous matter which they contain. They are usually known as bastard limestones, and the most of them contain numerous fossils. Though much inferior to the Mitchell and Niagara limestones for road-making purposes, they are superior to much of the gravel which has been used in the counties where they occur. Their local distribution and availability will be further discussed under the different county headings.

Shales of Indiana as a Source of Road Material.

The shales or laminated clays of Indiana belong mainly to three great geological horizons. These, named in the order of their geological age, are the New Albany or Genesee shale of the Devonian era, the Knobstone shales of the Lower Carboniferous or Mississippian era and the Carboniferous shales of the Coal Measures.

(a) *The New Albany or Genesee Shale.*

This shale forms the surface rock over an area eight to 15 miles wide, extending from the Ohio River near New Albany in a northwesterly direction to near Rensselaer, Jasper County. This area embraces a part of each of the following counties: Floyd, Clark, Scott, Jefferson, Jennings, Jackson, Bartholomew, Shelby, Johnson, Marion, Hendricks, Boone, Clinton, Tippecanoe, Carroll, White and Jasper. In the most of them the shale is heavily covered with drift, and its presence has been shown only by numerous bores sunk for water, gas or oil. In several of the southern counties, especially Clark, Scott and Jennings, its outcrops are numerous, and in Scott County it has been utilized in the construction of about one-third of the improved roads. In Carroll and White counties it is also exposed in numerous places along the principal streams.

Wherever found, this shale is a fissile or thin-layered blue-gray to black material, containing much iron sulphide and a great deal of bituminous matter. It is doubtless the possession of this bituminous matter which causes it to pack more solidly and grind up less freely than other shales. It can be easily and cheaply quarried wherever it occurs close to the surface. At New Albany it is 104 feet, and at other points well borings have shown it to run as high as 140 feet in thickness. The auditor of Scott County reports that where used as the base of the metal covering of roads, with two to five inches of creek gravel above, it forms a roadway which is more durable and less expensive for repairs than those made of either gravel or stone alone.*

Through the kindness of Mr. L. B. Case, of Indianapolis, I was informed that a similar Devonian shale is used extensively as a

*For a fuller account of its use as a road material in Scott County see the paper by R. W. Ellis in a subsequent section.

road material in the vicinity of Sandusky, Ohio. I therefore wrote to Prof. E. L. Mosely, of Sandusky, regarding its use, and he replied as follows: "The shale used is the Devonian black shale first described here by Newberry as Huron shale, but called by Orton 'Ohio shale.' In this (Erie) county, the smallest but one in the State, there are about 30 miles of shale road. In the making of the road no crusher is used, but the large pieces are broken with a hammer after being placed on the road, and the rest is done by the wagons and horses' hoofs. The roads are easily repaired and some of them have been in use for 20 years at least.

"I have driven with a buggy over nearly every mile of road in this county. The shale roads seem to me the best, and others have come to the same conclusion. Besides being smooth, they are not so dusty as the other roads. However, I have been told that in spring they sometimes are not as good as other roads. Moreover, they will not stand the wear that harder material will, and so are not as durable. It is only when a cheaply made road is preferred to a more costly and durable one that shale can be recommended."

From the statements of Prof. Mosely and those of Mr. Ellis I judge that the New Albany shale makes a fair road metal, but one that is less durable than a good limestone. Where other material is not available it will doubtless be far better to use it than to retain the old clay or dirt roads in use up to the present time.

(*b*) *Knobstone and Carboniferous Shales.*

The members of these two great groups of shales are all too soft and too easily ground up into mud to be used in the raw state as a road material. They offer, however, a practically unlimited supply of the finest of material for the making of paving brick. The time will come, and that before long, when such brick will be used on country roads, especially on the principal highways which connect the larger towns and county seats. The use of such brick will be mainly in those counties which are lacking in other good road material, but which possess shales suited in every way for the making of high-grade vitrified brick. In Indiana the Knobstone area, already mentioned as a source of creek gravel, and the Carboniferous area of the western and southwestern counties offer in abundance just such shales. Six large factories are already in

operation in these areas making paving brick for street purposes. In 1904 the output of these factories was 48,305,000 brick or block, valued at $545,721.*

The distribution and properties of the Indiana shales suitable for vitrified brick have been fully discussed by the writer in another connection.† Suffice it to say that they occur in practically unlimited quantities in the areas mentioned. In the Carboniferous area they directly overlie thick veins of the finest of bituminous coal suitable in every way for their burning. While the first cost of improving roads with such brick will probably be double that of a good stone road, they will, if properly built, be smoother, firmer and far more durable. The cost of annual repair will be reduced to a minimum, so that in the long run they will be the cheaper. The greatest cost would probably be in the foundations, which should be of some form of concrete; but the price of cement is much less now than a few years ago, so that the cost of foundations would be by no means prohibitive in a well-developed agricultural community.

Stone Crushing Plants of Indiana.

Large and permanent plants for preparing crushed stone for macadam purposes or railway ballast are operated at a number of places throughout the southern two-thirds of the State. Each of these plants is situated on a spur of some railway and the stone dumped directly into the cars from storage bins. The following list of companies, with location and kind of rock crushed, is given for the benefit of those interested:

*For a full account of the paving brick industry in Indiana and the use of vitrified brick for street paving, see the 29th (1904) Rept. of this Dept., pp. 516-570.

†Loc. Cit., pp. 69-377.

A List of the Permanently Located Stone Crushing Plants of Indiana.

Name of Firm.	Location.	Kind of Stone.
W. F. Goff Stone Co	Kentland, Newton County	Niagara.
Edw. Hely	Monon, White County	Niagara.
Casparis Stone Co	Kenneth, Cass County	Niagara.
Thos. Bridges' Sons	Wabash, Wabash County	Niagara.
Wabash Stone Co	Wabash, Wabash County	Niagara.
Erie Stone Co	Huntington, Huntington Co	Niagara.
Keefer & Bailey	Huntington, Huntington Co	Niagara.
F. A. Brickley	Markle, Huntington County	Niagara.
Shoemaker Bros	Bluffton, Wells County	Niagara.
Meyer Stone Co	Bluffton, Wells County	Niagara.
J. S. Bowers Co	Decatur, Adams County	Niagara.
E. Woods & Co	Pleasant Mills, Adams County	Niagara.
Portland Stone and Lime Co	Portland, Jay County	Niagara.
Baltes Stone Co	Montpelier, Blackford County	Niagara.
Marion Stone Co	Marion, Grant County	Niagara.
Chaffin Bros. Stone Co	Kokomo, Howard County	Niagara.
Leach & Co	Kokomo, Howard County	Niagara.
Wilson Stone Co	Kokomo, Howard County	Niagara.
Deffenbaugh & Co	Kokomo, Howard County	Niagara.
Interurban Stone Co	Kokomo, Howard County	Niagara.
Delphi Crushed Stone Co	Delphi, Carroll County	Niagara.
Pierce Stone Co	Delphi, Carroll County	Niagara.
Armfield & Cartwright	Ridgeville, Randolph County	Niagara.
Mock Stone Co	Muncie, Delaware County	Niagara.
Eaton Stone Co	Eaton, Delaware County	Niagara.
L. C. Nicoson	Alexandria, Madison County	Niagara.
David V. Miller	Ingalls, Madison County	Niagara.
J. D. Torr	Oakalla, Putnam County	Mitchell.
J. B. Hillis	Greencastle, Putnam County	Mitchell.
Big Four Stone Co	New Point, Decatur County	Niagara.
Greensburg Limestone Co	Greensburg, Decatur County	Niagara.
Westport Stone Co	Westport, Decatur County	Niagara.
St. Paul Stone Quarry Co	St. Paul, Decatur County	Niagara.
Spencer Stone Co	Spencer, Owen County	Mitchell.
Southern Indiana Railway Co	Williams, Lawrence County	Mitchell.
Mitchell Lime Co	Mitchell, Lawrence County	Mitchell.
W. W. Franklin	West Franklin, Posey County	Carboniferous limestone.
Marengo Manufacturing Co	Marengo, Crawford County	Mitchell.
J. B. Speed & Co	Milltown, Crawford County	Mitchell.
Eichel Lime & Stone Co	Milltown, Crawford County	Mitchell.

Road Statistics of Indiana.

In order to secure the more important statistics concerning the improved roads of the State a blank form was sent out early in November, 1905, to each County Auditor, together with a letter of explanation and a stamped return envelope. Much difficulty was experienced in getting returns from a number of the counties. In some the auditor "did not have time to look the matter up." In others "there were no records of the roads kept," and in still others nothing whatever could be made out of the statistics returned. In such instances the forms were sent back, either to the County Surveyor, one of the County Commissioners or some other citizen who had sufficient ability and interest enough in the welfare of the county to attempt to properly fill out the blank. The time may come, and doubtless will, when competency rather than politics will be the chief factor in the choosing of as important an officer as the County Auditor. May the day be hastened.

A sample of two of the returned forms are herewith given, to show the right and the wrong way of doing things. From the first the table needed for insertion at the head of the county descriptive matter was made up in five minutes, while from the second there was no information at all to be derived.

STATISTICS OF ROADS IN THE STATE OF INDIANA FOR THE YEAR 1905.

1. Total number of miles of public roads in the county, 675.
2. Number of miles of improved roads, 216.
3. Number of miles improved with gravel, 102½.
4. Number of miles improved with crushed stone, 113½.
5. Average original cost of stone roads per mile, $3,200.
6. Average original cost of gravel roads per mile, $2,000.
7. Total original cost of improved roads in the county to date, $567,200.
8. Approximate annual cost of repairs per mile on gravel roads five years old, $70.
9. Approximate annual cost of repairs per mile on stone roads five years old, $25.
10. Number of miles of improved roads built in 1905 (a) gravel, 3; (b) stone, 7.
11. Number of miles of improved roads contracted for 1906, (a) gravel, 4; (b) stone, 0.
12. When were the first improved roads constructed in the county? 1889.
13. What proportion of the total mileage of improved roads has been constructed since 1895? 10 per cent.
14. Are the farmers of the county well satisfied with the investment in improved roads? Yes.

STATISTICS OF ROADS IN THE STATE OF INDIANA FOR THE YEAR 1905.

1. Total number of miles of public roads in the county, 150.15.
2. Number of miles of improved roads. ———.
3. Number of miles improved with gravel, 140.90.
4. Number of miles improved with crushed stone, 9¼.
5. Average original cost of stone roads per mile. Do not know.
6. Average original cost of gravel roads per mile. Do not know.
7. Total original cost of improved roads in the county to date, $———.
8. Approximate annual cost of repairs per mile on gravel roads five years old. Ans.—$15,000 appropriated annually for repairs.
9. Approximate annual cost of repairs per mile on stone roads five years old, $———.
10. Number of miles of improved roads built in 1905, (a) gravel, none; (b) stone, none.
11. Number of miles of improved roads contracted for 1906, (a) gravel, none; (b) stone, none.

12. When were the first improved roads constructed in the county? Do not know.
13. What proportion of the total mileage of improved roads has been constructed since 1895? Do not know.
14. Are the farmers of the county well satisfied with the investment in improved roads? I believe they are.

The answers to question one were desired in order to show the percentage of improved roads in each county and in the State.

From the proper answers to questions five and six one can get at the relative cost of gravel and stone roads in each county and the average cost of such roads in the State, also the total cost of improved roads in both county and State. Where the roads have been improved by the townships or by the working out of the road tax, as has been the case in many of the northern and eastern counties, an estimate of $750 per mile for gravel roads and $1,000 per mile for stone roads was made, when no estimate was given by the person sending in the form.

In order to know the comparative cost of keeping up both stone and gravel roads in each county and in different sections of the State, questions 8 and 9 were asked, while from the answers to 10 and 11 the present status of the good roads question in each county can be pretty accurately gauged. The answers to Nos. 12 and 13 enable one to judge as to when the demand for good roads began in the different counties and about when it was the most active. From the replies received it is evident that fully 70 per cent. of the improved roads of the southern half of the State have been built within the past ten years, while in the northern half not over 30 per cent. have been built during that period.

From the forms, tables of statistics have been made up and inserted at the head of the descriptive matter of the respective counties in the subsequent sections. The name of the person furnishing the information is given at the foot of each county table, so that if either praise or protest is to be registered relative to the correctness of the information it will fall upon the proper person.

Finally from the forms the following general table, showing in condensed form the more important statistics, has been compiled:

Road Statistics of the State of Indiana.

COUNTY.	Miles of Public Roads.	Miles of Improved Roads.	Percentage of Roads Improved.	Miles Improved with Gravel.	Miles Improved with Crushed Stone.	Average Original Cost of Gravel Roads per Mile.	Average Original Cost of Stone Roads per Mile	Total Original Cost of Improved Roads.	Miles of Toll Roads.	Remarks.
Adams	675	216	32	102.5	113.5	$2,000	$3,200	$567,200	.....	
Allen	900	450	50	450	....	1,000	....	450,000	......	All improved roads built by township trustees and farmers.
Bartholomew	900	276	30.6	250	26	2,000	3,200	583,200	......	
Benton	775	230	30	230	....	2,500	....	487,500	......	Includes 50 miles of township roads at $750 per mile.
Blackford	360	130	36.1	130	......	1,800	....	235,040	......	
Boone	816	600	73.5	600	....	1,200	....	720,000	......	
Brown	350	30	8.6	30	.....	1,028	....	30,840	.....	
Carroll	847	230	28.3	215	15	1,600	2,400	380,000	.....	
Cass	988	213	21.5	202	11	1,700	2,500	370,900	.....	
Clark	600	171	28.5	35	136	808	993	138,546	25	Cost of toll roads not included in total cost.
Clay	800	218	27.2	186	32	2,000	2,500	452,000	......	
Clinton	700	460	65.7	460	....	2,100	....	966,000	......	
Crawford	229	7⅞	3.4	....	7⅞	....	1,731	14,110	......	
Daviess	860	106	12.3	70	36	1,875	2,125	208,050	......	
Dearborn	255	20	7.8	....	20	....	....	....	20	All improved roads are operated as toll roads, and cost is not known.
Decatur	600	175	29.2	8	167	1,500	2,500	429,500	......	
Dekalb	360	125	34.7	125	....	750	....	93,750	.....	All improved roads were built by the townships.
Delaware	800	600	75	600	....	1,000	....	600,000	......	All improved roads were built by the townships or are abandoned toll roads.
Dubois	700	32	4.6	....	32	....	3,062	98,225	......	
Elkhart	580	312	53.8	312	....	800	....	249,600	......	All improved roads have been built by the townships.
Fayette	386	270	70	270	....	750	....	202,500	.....	All improved roads were built by the townships, and the cost is estimated.
Floyd	350	126	36	90	36	400	1,000	42,000	30	Gravel roads built by townships. Cost of toll roads not included in total cost.
Fountain	1,200	502	41.8	500	2	2,000	2,500	1,005,000	......	
Franklin	1,000	143	14.3	143	....	2,000	....	286,000	....	
Fulton	682	52	7.6	52	....	1,231	....	64,040	......	44.54 miles built by townships; 7.46 bought from toll road company for $19,500.
Gibson	1,350	136.87	10.1	31.85	105.02	2,659	2,431	380,060	......	
Grant	900	460	51.1	460	....	2,000	....	920,000	......	
Greene	900	350	38.8	325	25	1,600	2,500	576,000	......	About 300 miles of the improved roads are built of a combination of stone and gravel.

Road Statistics of the State of Indiana—Continued.

COUNTY.	Miles of Public Roads.	Miles of Improved Roads.	Percentage of Roads Improved.	Miles Improved with Gravel.	Miles Improved with Crushed Stone.	Average Original Cost of Gravel Roads per Mile.	Average Original Cost of Stone Roads per Mile.	Total Original Cost of Improved Roads.	Miles of Toll Roads.	Remarks.
Hamilton	700	500	71.4	500	......	1,200	....	600,000	......	
Hancock	605	402	66.3	402	......	900	....	361,800	......	
Harrison	675	55	8.1	11	44	....	1,800	64,800	19	Cost of 11 miles of gravel toll road and 8 miles of stone toll road not included in total cost.
Hendricks	820	210	25.6	187	23	1,850	2,683	407,659	......	
Henry	500	435	87	435	......	1,800	....	783,000	......	
Howard	600	263	43.8	263	......	2,400	....	631,200	......	
Huntington	856	496	58	485	11	2,000	1,000	981,000	......	The 11 miles of stone road built by the townships. Cost estimated at $1,000 per mile.
Jackson	650	500	76.9	490	10	1,057	2,000	537,696	......	
Jasper	600	47	7.8	47	......	2,500	....	117,500	......	
Jay	800	300	37.5	265	35	1,800	2,700	571,500	......	
Jefferson	790	107.3	13.6	......	107.3	....	1,282	177,363	......	Includes 54.71 miles of toll roads purchased by the county at $2,075 per mile.
Jennings	621	218	35.1	6	212	1,348	1,975	426,788	......	
Johnson	620	240	38.7	240	......	1,250	....	300,000	......	
Knox	580	264	45.5	200	64	1,800	2,000	488,000	......	
Kosciusko	1,300	254	19.5	250	4	700	1,000	179,000	......	All improved roads were built by the townships and the cost is estimated.
Lagrange	826	275	33.3	275	......	750	....	206,250	......	All improved roads have been built by farmers, and the cost is estimated.
Lake	700	158	22.5	71	87	3,013	4,330	590,753	......	
Laporte	1,200	89	7.4	......	89	....	4,000	356,000	......	
Lawrence	600	350	58.3	275	75	1,500	1,900	555,000	......	
Madison	900	325	36.1	325	......	3,500	....	1,137,500	......	
Marion	1,190	800	67.2	800	......	1,100	....	880,000	......	
Marshall	800	450	56.2	450	......	315	....	141,750	......	All improved roads built by working out the road tax.
Martin	400	65	16.2	30	35	2,000	1,900	125,930	......	
Miami	1,120	504	45	504	......	2,000	....	332,000	......	398 miles built by working out the road tax. Estimated at $300 per mile.
Monroe	865	165	19.1	......	165	....	2,200	365,000	......	
Montgomery	827	450	54.4	450	......	1,500	....	675,000	......	
Morgan	500	140	28	100	40	900	1,700	158,000	......	
Newton	632	117	18.5	11	106	1,100	1,800	192,096	......	
Noble	850	600	70.5	600	......	750	....	450,000	......	All township roads, with an estimated cost of $750 per mile.

Ohio	160	35.5	22.2	4	31.5	1,200	1,964	66,671	10	
Orange	700	168	24	40	128	1,250	1,800	280,000	......	
Owen	692	200	28.9	30	170	1,900	1,800	363,000	......	
Parke	1,200	600	50	580	20	1,500	2,000	910,000	......	
Perry	800	0	0	......	......	......	......	......	......	
Pike	1,200	36.4	3	......	36.4	......	2,530	92,100	......	One-half of the roads have a top dressing of White River gravel.
Porter	1,000	110	10.1	91	19	3,150	3,100	345,000	......	
Posey	500	94.24	18.8	30.99	63.25	2,456	3,785	297,520	......	
Pulaski	875	80	9.1	67	13	1,383	2,600	126,500	......	
Putnam	900	635	70.5	335	300	1,500	2,000	1,102,500	......	
Randolph	900	300	33.3	300	......	1,500	......	450,000	......	
Ripley	462	135	29.2	15	120	......	2,500	300,000	......	The abandoned right of way of a railroad, 15 miles in length, was made a public gravel road.
Rush	1,100	550	50	540.75	9.25	1,500	3,000	539,100	......	Includes 400 miles of township gravel roads, at an estimated cost of $750 per mile.
Scott	400	116.36	29	37.8	29.14	1,047	1,198	128,214	......	49.4 miles of road improved with black shale at a cost of $1,087 per mile.
Shelby	600	285	47.5	285	......	1,500	......	427,500	......	
Spencer	1,008	29.5	2.9	......	29.5	......	2,000	58,510	......	
Starke	650	73	11.2	60	13	1,250	2,200	103,600	......	
St. Joseph	870.7	238.7	27.4	238.7	......	750	......	179,025	......	All improved roads are built by townships at estimated cost of $750 per mile.
Steuben	700	300.5	42.9	300	⅛	500	......	150,000	......	All improved roads built by working out road tax.
Sullivan	974	332	34.1	272	60	2,600	3,200	844,623	......	
Switzerland	345	108	31.3	28	80	1,300	1,800	180,400	......	
Tippecanoe	825	400	48.4	400	......	850	......	340,500	......	
Tipton	560	410	73.2	395	15	2,200	3,500	921,500	......	
Union	280	251	89.6	251	......	600	......	150,600	......	All improved roads built by the townships.
Vanderburgh	600	129.6	21.6	52.5	77	750	1,000	116,475	......	All improved roads built by the townships. Cost estimated.
Vermillion	800	300	37.5	300	......	1,800	......	540,000	......	
Vigo	725	220	30.3	220	......	1,414	......	311,187	......	
Wabash	600	200	33.3	200	......	750	......	150,000	......	
Warren	610	186	30.5	186	......	2,100	......	390,600	......	
Warrick	750	29	3.8	......	29	......	1,785	51,760	......	
Washington	1,500	113	7.5	8	105	900	2,000	183,200	8	Cost of 8 miles of toll road not included.
Wayne	828	702	84.7	702	......	1,237	......	868,500	......	Includes 550 miles of township roads at $750 per mile.
Wells	780	452	57.9	440	12	1,800	2,800	825,600	......	
White	750	143.5	19.1	80.5	63	2,000	2,300	305,900	......	
Whitley	651	542	83.2	542	......	1,150	......	623,330	......	531 miles of township roads, built at an average cost of $1,150 per mile.
Totals	68,285	23,937	*35.1	20,582	3,355	*$1,403	*$2,221	$36,065,841	112	

*Denotes average.

Road Statistics of the State of Indiana—Continued.

COUNTY.	Miles of Public Roads.	Miles of Improved Roads.	Percentage of Roads Improved.	Miles Improved with Gravel.	Miles Improved with Crushed Stone.	Average Original Cost of Gravel Roads per Mile.	Average Original Cost of Stone Roads per Mile.	Total Original Cost of Improved Roads.	Miles of Toll Roads.	Remarks.
Hamilton	700	500	71.4	500	......	1,200	....	600,000	......	
Hancock	605	402	66.3	402	......	900	....	361,800	......	
Harrison	675	55	8.1	11	44	....	1,800	64,800	19	Cost of 11 miles of gravel toll road and 8 miles of stone toll road not included in total cost.
Hendricks	820	210	25.6	187	23	1,850	2,683	407,659	......	
Henry	500	435	87	435	......	1,800	....	783,000	......	
Howard	600	263	43.8	263	......	2,400	....	631,200	......	
Huntington	856	496	58	485	11	2,000	1,000	981,000	......	The 11 miles of stone road built by the townships. Cost estimated at $1,000 per mile.
Jackson	650	500	76.9	490	10	1,057	2,000	537,696	......	
Jasper	600	47	7.8	47	......	2,500	....	117,500	......	
Jay	800	300	37.5	265	35	1,800	2,700	571,500	......	
Jefferson	790	107.3	13.6	......	107.3	....	1,282	177,363	......	Includes 54.71 miles of toll roads purchased by the county at $2,075 per mile.
Jennings	621	218	35.1	6	212	1,348	1,975	426,788	......	
Johnson	620	240	38.7	240	......	1,250	....	300,000	......	
Knox	580	264	45.5	200	64	1,800	2,000	488,000	......	
Kosciusko	1,300	254	19.5	250	4	700	1,000	179,000	......	All improved roads were built by the townships and the cost is estimated.
Lagrange	826	275	33.3	275	......	750	....	206,250	......	All improved roads have been built by farmers, and the cost is estimated.
Lake	700	158	22.5	71	87	3,013	4,330	590,753	......	
Laporte	1,200	89	7.4	......	89	....	4,000	356,000	......	
Lawrence	600	350	58.3	275	75	1,500	1,900	555,000	......	
Madison	900	325	36.1	325	......	3,500	....	1,137,500	......	
Marion	1,190	800	67.2	800	......	1,100	....	880,000	......	
Marshall	800	450	56.2	450	......	315	....	141,750	......	All improved roads built by working out the road tax.
Martin	400	65	16.2	30	35	2,000	1,900	125,930	......	
Miami	1,120	504	45	504	......	2,000	....	332,000	......	398 miles built by working out the road tax. Estimated at $300 per mile.
Monroe	865	165	19.1	......	165	....	2,200	365,000	......	
Montgomery	827	450	54.4	450	......	1,500	....	675,000	......	
Morgan	500	140	28	100	40	900	1,700	158,000	......	
Newton	632	117	18.5	11	106	1,100	1,800	192,096	......	
Noble	850	600	70.5	600	......	750	....	450,000	......	All township roads, with an estimated cost of $750 per mile.

Ohio	160	35.5	22.2	4	31.5	1,200	1,964	66,671	10	
Orange	700	168	24	40	128	1,250	1,800	280,000	.....	
Owen	692	200	28.9	30	170	1,900	1,800	363,000	.....	
Parke	1,200	600	50	580	20	1,500	2,000	910,000	.....	
Perry	800	0	0	......	......	....	....	....	.....	
Pike	1,200	36.4	3	......	36.4	....	2,530	92,100	.....	One-half of the roads have a top dressing of White River gravel.
Porter	1,000	110	10.1	91	19	3,150	3,100	345,000	.....	
Posey	500	94.24	18.8	30.99	63.25	2,456	3,785	297,520	.....	
Pulaski	875	80	9.1	67	13	1,383	2,600	126,500	.....	
Putnam	900	635	70.5	335	300	1,500	2,000	1,102,500	.....	
Randolph	900	300	33.3	300	......	1,500	....	450,000	.....	
Ripley	462	135	29.2	15	120	....	2,500	300,000	.....	The abandoned right of way of a railroad, 15 miles in length, was made a public gravel road.
Rush	1,100	550	50	540.75	9.25	1,500	3,000	539,100	.....	Includes 400 miles of township gravel roads, at an estimated cost of $750 per mile.
Scott	400	116.36	29	37.8	29.14	1,047	1,198	128,214	.....	49.4 miles of road improved with black shale at a cost of $1,087 per mile.
Shelby	600	285	47.5	285	......	1,500	....	427,500	.....	
Spencer	1,008	29.5	2.9	......	29.5	....	2,000	58,510	.....	
Starke	650	73	11.2	60	13	1,250	2,200	103,600	.....	
St. Joseph	870.7	238.7	27.4	238.7	......	750	....	179,025	.....	All improved roads are built by townships at estimated cost of $750 per mile.
Steuben	700	300.5	42.9	300	⅓	500	....	150,000	.....	All improved roads built by working out road tax.
Sullivan	974	332	34.1	272	60	2,600	3,200	844,623	.....	
Switzerland	345	108	31.3	28	80	1,300	1,800	180,400	.....	
Tippecanoe	825	400	48.4	400	......	850	....	340,500	.....	
Tipton	560	410	73.2	395	15	2,200	3,500	921,500	.....	
Union	280	251	89.6	251	......	600	....	150,600	.....	All improved roads built by the townships.
Vanderburgh	600	129.6	21.6	52.5	77	750	1,000	116,475	.....	All improved roads built by the townships. Cost estimated.
Vermillion	800	300	37.5	300	......	1,800	....	540,000	.....	
Vigo	725	220	30.3	220	......	1,414	....	311,187	.....	
Wabash	600	200	33.3	200	......	750	....	150,000	.....	
Warren	610	186	30.5	186	......	2,100	....	390,600	.....	
Warrick	750	29	3.8	......	29	....	1,785	51,760	.....	
Washington	1,500	113	7.5	8	105	900	2,000	183,200	8	Cost of 8 miles of toll road not included.
Wayne	828	702	84.7	702	......	1,237	....	868,500	.....	Includes 550 miles of township roads at $750 per mile.
Wells	780	452	57.9	440	12	1,800	2,800	825,600	.....	
White	750	143.5	19.1	80.5	63	2,000	2,300	305,900	.....	
Whitley	651	542	83.2	542	......	1,150	....	623,330	.....	531 miles of township roads, built at an average cost of $1,150 per mile.
Totals	68,285	23,937	*35.1	20,582	3,355	*$1,403	*$2,221	$36,065,841	112	

*Denotes average.

From the table we learn that in Indiana there are approximately 68,285 miles of public roadway, of which 23,937 miles, or 35.1 per cent., have been improved with either gravel or stone. Of the improved roads, 112 miles are owned by private corporations who collect toll for travel over them. These toll roads are all in the extreme southern end of the State and, with one exception, in counties which border upon the Ohio River. Their cost was not ascertained, and therefore does not enter into the total original cost of improved roads as given in the table.

Adding to this mileage of toll roads 15 additional miles which were donated in Ripley County, we have 127 miles (101 of stone and 26 of gravel) whose cost is not reckoned in the table. Subtracting these from their respective columns, we have 20,556 miles of gravel road, built at a total cost of $28,838,225, or an average cost of $1,403 per mile. Since one-half or more of this was built by the townships or by working out the road tax at a cost ranging between $300 and $1,200 per mile, the average cost is much lower that it would be if only roads built by contract and sale of bonds under the present law had been considered.

We find also that 3,254 miles of stone road have been built for $7,227,616, or an average of $2,221 per mile. The total original cost of improved roads in the State is shown to be $36,065,841. The sum expended for their repairs has probably been one-half as much, or more, though statistics are not available as to the amount.

Results of Physical Tests of Indiana Limestone for Road Making Purposes

ORDOVICIAN LIMESTONES.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight Per Cu. Foot, Pounds.	Water Absorbed Per Cu. Foot, Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
Average of 192 samples of limestone. Standard of comparison. See page 79.	2.7	165.7	1.39	5.7	8.7	3.4	11	32 59
Albert Stein, Richmond, Wayne County..	2.7	168.4	.89	4.5	8.9	9.6	6	15 28
Henry Schrœder, Rising Sun, Ohio County.	2.7	168.4	.46	5.5	7.3	4.7	9	15 98
Samuel Locke, Vevay, Switzerland County.	2.7	168.4	.57	5.4	7.5	4	8	25 46

Results of Physical Tests of Indiana Limestone for Road Making Purposes—Continued.

NIAGARA LIMESTONES.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight Per Cu. Foot, Pounds.	Water Absorbed Per Cu. Foot, Pounds.	Per Cent of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
W. F. Goff Stone Co., Kentland, Newton County.	2.7	168.4	.33	4.1	9.7	12	12	19 33
Casparis Stone Co., Logansport, Cass County.	2.65	165	1.31	......	... .	......	......	11 47
Edw. Heby, Monon, White County	2.7	168	1.04	.....	......	7.5	9	29 43
Delphi Stone Co., Delphi, Carroll County.	2.77	171.5	.75	5.09	7.86	10	14	14 42
Fred Showalter, Washington Township, Carroll County.	2.73	171.5	.50	8.73	4.58	12	21	7 45
Chaffin & Co., Kokomo, Howard County..	2.44	152.8	6.50	4.13	9.69	5.3	17	28 42
J. M. Leach & Co., Kokomo, Howard County.	2 45	153	6.21	4.2	9.6	......	8	46 63
Bridges & Son, Wabash, Wabash County.	2.56	159	2.43	4.6	8.7	......	.....	41 ......
Bridges & Son, Wabash, Wabash County.	2.8	171.5	.43	3.3	12.1	11.5	9	17 21
Wabash Stone Co., Wabash, Wabash County.	2.6	162.2	3.29	3.8	10.5	9.3	10	20 27
Keefer & Bailey, Huntington, Huntington County.	2.75	172	1.21	......	......	......	......	18 36
E. Woods & Co., Pleasant Mills, Adams County.	2.56	159	3.56	10.23	3.91	......	......	10 22
Jno. S. Bowers, Decatur, Adams County..	2.7	168	1.11	......	......	......	......	14 40
Meyers & Co., Bluffton, Wells County.....	2.7	168.4	1.65	6.3	6.3	10.8	13	9 37
Quarry near Rockford, Wells County. ...	2.7	165.3	3.29	5.1	7.8	13	14	22 37
Shoemaker Bros.. Bluffton, Wells County.	2.7	171.5	.55	5.8	6.9	13.5	8	14 29
Baltes Stone Co, Montpelier, Blackford County.	2.7	165.3	2.97	3.7	10.8	9.3	.....	35 52
Marion Stone Co, Marion, Grant County.	2.6	159	4.72	5.2	7.8	2.5	15	44 56
Ingalls, Madison County	2.7	168.4	.29	5.6	7.2	8	5	16 50
N. J. Nicoson, Alexandria, Madison County.	2.7	165.3	1.41	4.3	9.3	1.8	7	26 28
Dan'l Abbott, Frankton, Madison County	2.7	165.3	1.57	4.4	9.2	7.8	7	28 29
Armfield & Cartwright, Ridgeville, Randolph County.	2.65	165.3	.77	7.2	5.6	-7	6	11 19
Portland Lime and Stone Co., Portland, Jay County.	2.7	168.4	.69	7	5.7	4.5	8	19 45

Results of Physical Tests of Indiana Limestone for Road Making Purposes—Continued.

NIAGARA LIMESTONES—Continued.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight Per Cu. Foot, Pounds.	Water Absorbed Per Cu. Foot, Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
Griffin & Co., Noblesville, Hamilton County.	2.8	171.5	1.08	4.9	8.1	13.8	9	15 26
James Ochiltree, Rushville, Rush County	2.7	168.4	2.18	2.7	14.8	-5.3	6	34 65
Frank Moore, New Salem, Rush County..	2.6	162.2	2.32	12.7	3.1	4	5	13 24
Big Four Stone Co., New Point, Decatur County.	2.7	168.4	.93	3.5	11.3	9.3	10	12 34
Greensburg Limestone Co., Greensburg, Decatur County.	2.7	168.4	1.27	4.5	9	12	8	51 56
John Wiesahan, Weisburg, Dearborn County.	2.7	168.4	.62	4.8	8.3	2.5	8	44 59
Geo. Hotchkiss, Soapville, Switzerland County.	2.7	168.4	.80	4	9.9	.3	9	10 20
Richard Johnson, North Madison, Jefferson County.	2.6	165.3	3.21	5.2	7.8	3	12	36 53

DEVONIAN LIMESTONES.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight Per Cu. Foot, Pounds.	Water Absorbed Per Cu. Foot, Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
Lewis Solomon, Hope, Bartholomew County.	2.7	171.5	1.71	5.9	6.7	-1	5	20 41
D. M. Walker, Burnsville, Bartholomew County.	2.7	168.4	.96	6	6.7	-8.3	5	18 25
M. A. Rainey, Grammar, Bartholomew County.	2.5	159	1.37	6.2	6.5	8	8	38 49
L. C. Bunker, Greensburg, Decatur County.	2.6	159	2.99	4.7	8.5	......	9	8 38
William S. Baker, Hayden, Jennings County.	2.7	168.4	.93	3.2	12.6	8.5	9	49 97
I. B. Stearns, Brewersville, Jennings County.	2.7	168	.57	3.7	10.9	6.3	8	28 94
Thomas Croxton, Dillsboro, Dearborn County.	2.7	168.4	.78	4.8	8.3	9.8	7	67 100
David Robertson, Deputy, Jefferson County.	2.7	168.4	.43	4.7	8.5	- .3	7	53 81
Stephen Lewis, Hanover, Jefferson County.	2.5	159	3.58	12.3	3.2	-16	7	23 42
Wm. E. English, Lexington, Scott County.	2.65	165	2.27	3.3	12.3	2.7	9	28 103
City Quarry, Charlestown, Clark County..	2.6	162.2	1.41	5.6	7.1	3.5	8	17 52
B. L. Burtt, Jeffersonville, Clark County.	2.65	165	1.23	3.4	11.7	3	7	31 91

Results of Physical Tests of Indiana Limestone for Road Making Purposes—Continued.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight per Cu. Foot, Pounds.	Water Absorbed Per Cu. Foot, Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
HARRODSBURGH LIMESTONES.								
Indiana University Quarry, Bloomington, Monroe County.	2.7	168.4	3.32	10.6	3.8	-14.5	6	19 49
Roadside, one mile north of Bloomington, Monroe County.	2.6	165.3	.97	5.3	7.5	-3	7	23 62
BEDFORD OÖLITIC LIMESTONES.								
Hunter Valley Quarries, Bloomington, Monroe County.	2.4	149.7	4.44	10.8	3.7	-47.5	4	18 63
Lanesville & Corydon Pike Road Co., Edwardsville, Floyd County.	2.65	165	1.32	4.4	9	4.6	9	25 114
MITCHELL LIMESTONES.								
Jerry Clifford, Russellville, Putnam County.	2.67	165.3	.99	4.44	9.01	6	9	16 29
J. D. Torr, Oakalla, Putnam County......	2.69	168.4	.79	3.87	10.34	14	11	8 24
J. B. Hillis, Greencastle, Putnam County.	2.7	168.4	.43	4.31	9.22	4.3	7	13 22
Simpson McGaughey, Greencastle, Putnam County.	2.63	165.3	1.53	4.5	8.89	10	8	16 20
J. E. Oldshoe, Waveland, Montgomery County.	2.7	165.3	1.35	3.9	10.2	-5.2	5	23 43
Spencer Stone Co., Spencer, Owen County.	2.68	168.4	.88	3.68	10.87	6.3	10	8 21
Roadside Quarry, 1½ miles northwest of Spencer, Owen County.	2.6	162 2	3	3.4	11.8	-4.5	9	20 45
Jas. Blair, Bloomington, Monroe County..	2.6	165.3	1.7	3	13.4	9.3	13	30 41
F. M. Robinson, Bloomington, Monroe County.	2 6	162.3	2.16	3.5	11.5	10.5	12	14 74
Southern Indiana Railway Co., Williams, Lawrence County.	2.7	168	.7	4.1	9.7	12	8	34 141
Mitchell Lime Co., Mitchell, Lawrence County.	2.6	162.2	1.66	4.6	8.8	4	9	28 26
O. P. Turley, Orleans, Orange County.....	2.5	155.9	3	4.4	9.1	8	5	11 37
Jas. McKinster, Corydon, Harrison County	2.5	156	1.97	4.5	8.8	13.6	11	24 131
J. B. Speed & Co., Milltown, Crawford County.	2.66	165.3	.46	3.4	11.6	10	8	18 95
Marengo Manufacturing Co., Marengo, Crawford County.	2.65	165	1.61	3.7	10.8	8.9	9	16 53

Results of Physical Tests of Indiana Limestone for Road Making Purposes—Continued.

HURON LIMESTONES.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight per Cu. Foot, Pounds.	Water Absorbed Per Cu. Foot, Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
Geo. Cox, Bloomfield, Greene County	2.7	168.4	1.15	3	13.2	13	10	21 66
John Scott, Shoals, Martin County.........	2.6	162.3	2	3.2	12.4	8.5	9	18 67

CARBONIFEROUS LIMESTONES.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight per Cu. Foot, Pounds.	Water Absorbed Per Cu. Foot, Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
Kurtz Heirs, Princeton, Gibson County...	2.7	168	1.13	......	.....	.....	......	24 191
L. George, Petersburg, Pike County	2.75	172	.81	4.9	8.1	-22.5	9	24 71
Louis Meyer, Boonville, Warrick County.	2.7	168.4	.97	3.3	12.3	14	11	15 126
C. S. Laubscher, Evansville, Vanderburgh County.	2.7	168	1.38	4	10	11	8	17 52
W. M. Williams, Mt. Vernon, Posey County.	2.7	168	.82	1.8	21.7	9.8	8	43 56
Wyatt H. Williams, Mt. Vernon, Posey County.	2.7	168	1.67	3.5	11.3	11.5	15	22 108

SECTION VI.

ROADS AND ROAD MATERIALS OF THE NORTHERN THIRD OF INDIANA.

EMBRACING THE COUNTIES OF STEUBEN, LAGRANGE, ELKHART, ST. JOSEPH, LAPORTE, PORTER, LAKE, STARKE, MARSHALL, KOSCIUSKO, NOBLE, DEKALB, WHITLEY, FULTON, PULASKI, JASPER, NEWTON, BENTON, WHITE, CASS, MIAMI, WABASH, HUNTINGTON, WELLS, ADAMS, JAY, BLACKFORD, GRANT, HOWARD AND CARROLL.

BY L. C. WARD.

The territory covered by this report has for its southern limit the south boundary of the counties of the fourth tier from the north, and for its northern boundary the State line. Within these limits all of the counties have been visited except Lake and Porter*,in the northwest corner, and Allen in the northeast portion.

Topography.—The topography of the entire territory is of the glacial type, little of it falling below the 800-foot contour line and only in a few places rising above the 1,000-foot contour. As a rule the surface is plane, broken by the valleys of the Wabash, the Kankakee and the Maumee, and their tributaries, and by the various forms of glacial relief, drumlins, moraines and over-wash ridges. The general slope of the plane is toward the south, but the irregular occurrence of ridges often lifts portions of the southernmost territory above the 800-foot contour.

Drainage.—The principal drainage lines in the area are the Wabash, with its two largest northern tributaries, Tippecanoe and Eel, and its southern tributaries, Salamonie and Mississinewa; the Kankakee, Iroquois, Yellow and Elkhart rivers, and the Maumee system. Besides these larger streams there are numerous creeks, and the peculiar lake drainage which is so

*Neither Lake nor Porter counties contain any gravel deposits of importance, nor is there an outcrop of stone in either of the two. A brief description of the topography of each of the two counties has been prepared by W. S. Blatchley, and is inserted in the present section.

often associated with glacial topography. One great water-shed is the Erie-Saginaw moraine which enters the State upon its northern boundary and extends southwest as far as Monticello, in White County. Within this morainal belt lie probably 80 per cent. of the Indiana lakes. From its western flank proceed the waters of the Tippecanoe, and from the eastern side, those of the Eel River. A very much smaller moraine, the Maxinkuckee, enters the State in St. Joseph County and extends south to Rochester. This moraine forms the divide between the Kankakee and Tippecanoe systems. On the south side of the Wabash a number of ridge-like moraines enter the State concentrically from Ohio, and sweep round in great arcs to the Wabash. The outer margin of these moraines is swept by small rivers, as the Salamonie; and two of these ridges, one from the northeast, the other from the southeast, meet near Fort Wayne, and separate the Maumee system from the Wabash.

Geology.—The geology of the region, with regard to the underlying rocks, is not very complicated. At Remington, in Jasper County, some rocks, probably Mississippian, appear as shales; and there are a few outcrops of the Corniferous in the southern part of the territory. Everywhere else, however, the Niagara is the prevailing formation. It is often curiously folded and faulted and there are great variations, sometimes within a hundred yards, in its depth below the surface. Usually these variations are accounted for by the sudden dip of the strata; but in at least one locality the quick drop is believed to be due to the excavation of a pre-glacial channel.*

The surface geology of the area is not so simple. Perhaps one-third of the whole territory is till-plain, of the Wisconsin stage. About one-sixth is sand-plain and sand-hill country, the over-wash from the front of the glacier; and the remainder is morainal, consisting of the great Erie-Saginaw lobe, the Maxinkuckee moraine, and smaller ridges lying south of the Wabash. Here and there small detached ridges rise out of the till-plains, sometimes drumlins, oftener kames. It is easily possible in this district to find practically all the type forms of glacial topography; and there are many striking deviations from the types.

*Leverett, U. S. G. S. Water Supply and Irrigation Papers, No. 21, Wabash County.

the coarser particles settle first. The problem, then, is to find the place of origin of the gravel, and the direction of the stream which transported it. In the territory covered, practically all the gravel is of glacial origin, being the ground-up fragments of boulders carried down by the ice-sheets during the Glacial Period. The transporting water must have been largely derived from the melting of the ice. In the majority of cases, the streams are no longer in existence; but any of our rivers that flow from or through a morainal region show not only that they once carried a far greater volume of water than they now do, but also a considerable quantity of gravel in favorable parts of the channel. An exception must be made of such rivers as the Iroquois and the Kankakee, for here the gravel deposits have been so deeply buried with sand and "till" that the streams move sluggishly in mud banks and have mud bottoms.

In brief, we may say that the gravels of Northern Indiana are found either (1) in moraines where they have lain since the time of the ice-period; (2) in eskars, or long crooked ridges which mark the course of streams beneath the ice; (3) in "aprons" spreading out for 200 or 300 yards in front of the morainal hills; where the gravel is simply the overwash from the moraine; (4) around the shores of former lakes and ponds, and (5) in beds along former streams which broke through the morainal hills, and whose former passage is marked by a gap in the range. Besides these places, all directly connected with the old glacier, the rivers and larger streams afford larger or smaller deposits. These occur either (1) in the trenches or ancient flood plains, (2) on the inner curves of winding streams, or (3) in recent sandbars. There are some smaller deposits which are irregular; but they comprise an insignificant per cent. of the whole.

The method of investigating the gravel resources of a given region consisted of a study of its topography whereby an idea might be obtained of its relations to moraines, and the likely places for gravel thus discovered; and after this a search by means of holes for the limits of the individual deposits. The best means for this search is afforded by spade and post-hole digger; a drill was also employed where the bottom of a deposit could not be found with the other implements. It is not pretended that all the gravel in any section has been found. Such a statement can be made only

after every acre of land has been tested. It is believed, however, that the larger deposits have been located and their size closely estimated. The one point steadily kept in mind was the location of gravel within reasonable hauling distance of all roads likely to be improved. Where deposits were already known to exist in sufficient quantity to accomplish this, most time was occupied in forming an estimate as to their size. In places where no gravel was known an attempt was always made to locate gravel.

As a rule, no attention was given to deposits of less than 10,000 cubic yards or the amount required to build five miles of road. Such a deposit is here termed "workable." Smaller ones were neglected unless the scarcity of material or the close proximity of several small beds rendered them valuable.

STEUBEN COUNTY.

Area in square miles	311
Population in 1900	15,219
Miles of public roads	700
Miles of improved roads	300.5
Percentage of roads improved	42.9
Miles improved with gravel*	300
Miles of crushed stone	.5
Average original cost of gravel roads per mile	$500
Total original cost of improved roads	$150,000
Annual cost of repairs per mile on gravel roads 5 years old	$100
Miles of improved roads (gravel) built in 1905	7
First improved roads built	1850
Miles of improved roads built since 1895	40
Satisfaction of farmers with investment in improved roads	Good
Authority	Elmer Orewiler, County Surveyor

*All improved roads are built by the township or by working out the road tax.

This county is in the extreme northeastern corner of the State. In many respects it is the most beautiful portion of Indiana, the topography of at least half the county being of the knob-and-basin type. Here the drift is piled into great mounds, many of them being 100-150 feet above the basin. In the valleys there are a number of lakes, about a hundred for the county.

This is distinctly a morainal county, for the most part being on the interlobate moraine between the Erie and Saginaw lobes. The southeastern third of the county is Erie, with a till surface stratum 20 to 40 feet thick. The northwestern third is Saginaw,

mainly sand and gravel. Between the two is a transition belt, partly sand and gravel, partly clay. The moraine is interrupted by a till plain in the southeastern part of the county, and by the valley of Pigeon River in the northwestern corner. These two tracts comprise all the level land in the county.

In general, it may be said that this county is a gravel area. The usual section in the moraine territory is clay or till, 4 to 10 feet, gravel and sand 20 to 100 feet. Along the streams the clay has in many places been entirely eroded, leaving the gravel as the surface soil, which extends down perhaps 80 feet. On the till plain, the clay extends to a depth of 8 to 40 feet, with a substratum of gravel. Even in the Erie moraine, stream action has removed so much of the heavy drift-clay that the gravel is usually accessible. There is no place in the county more than three miles from good gravel, and at least 75 per cent. of the roads can be graveled with a haul of less than two miles.

Angola and Vicinity.

Angola lies on the interlobate moraine, built upon three or four of the drift mounds. It is located rather on the Saginaw side, so that sand and gravel are the predominating soil constituents. The hills are clay-covered to a depth of 3 to 5 feet, with 15 to 20 feet of gravel just below. Then comes 2 to 4 feet of hard-pan, succeeded by gravel which extends down at least 80 feet and probably much deeper.

One-half mile south of Angola a pit at the base of a knoll shows:

Section of Pit One-half Mile South of Angola.

		Feet.
1.	Clay	4
2.	Sand and gravel	6
3.	Hard pan	4
4.	Gravel	8

Further south, the sandy aspect of the surface gives place to clay, the influence of the Erie lobe beginning to affect the soil.

Just west of Angola, there is a pit which has yielded probably five or six thousand yards of gravel, and which is good for a great deal more. The section here shows:

Section of Pit Just West of Angola.

		Feet.
1.	Clay	4
2.	Sand and gravel	20
3.	Hard pan	2

At the cross roads two and a half miles west from Angola, the cut made in grading the road shows a vast amount of gravel, probably 100,000 yards being in sight. It is of good quality and can be worked with little expense. The gravel face is so great that the surface clay might be allowed to mix with the gravel without detriment to the value of the latter for road material.

Fox Lake, two miles southwest from Angola, is situated between clay knolls. There is practically no gravel in this immediate vicinity, wells being 50 to 75 feet deep before gravel is struck which yields enough water.

Hog-back Lake and Vicinity.

This lake takes its name from a great ridge skirting its northern and eastern shores. It is a typical kame, probably half a mile long, from 100 to 250 yards wide at the base, tapering to 10 to 20 yards at the top, and varying from 20 to 180 feet in height. It runs for half its length without any variation in level, and looks exactly like a railroad "fill" probably 80 feet high. The entire ridge is composed of gravel and boulders, and will furnish several hundreds of thousands of yards.

The dredge has lowered the lake and left a strip of old lake bottom from 20 to 80 yards wide composed of marl, peat or gravel. There is a great amount of fine washed gravel to be had here without stripping.

Area Northwest of Angola.

From this point west, across the county line, the hills are all gravel, capped sometimes with a heavy clay; but the gravel can be removed at the bases of the knolls with little expense for stripping.

In Mill Grove Township, in the northwestern corner of the county, practically every hill is a gravel bed, and the plain surfaces here are also gravel.

mainly sand and gravel. Between the two is a transition belt, partly sand and gravel, partly clay. The moraine is interrupted by a till plain in the southeastern part of the county, and by the valley of Pigeon River in the northwestern corner. These two tracts comprise all the level land in the county.

In general, it may be said that this county is a gravel area. The usual section in the moraine territory is clay or till, 4 to 10 feet, gravel and sand 20 to 100 feet. Along the streams the clay has in many places been entirely eroded, leaving the gravel as the surface soil, which extends down perhaps 80 feet. On the till plain, the clay extends to a depth of 8 to 40 feet, with a substratum of gravel. Even in the Erie moraine, stream action has removed so much of the heavy drift-clay that the gravel is usually accessible. There is no place in the county more than three miles from good gravel, and at least 75 per cent. of the roads can be graveled with a haul of less than two miles.

Angola and Vicinity.

Angola lies on the interlobate moraine, built upon three or four of the drift mounds. It is located rather on the Saginaw side, so that sand and gravel are the predominating soil constituents. The hills are clay-covered to a depth of 3 to 5 feet, with 15 to 20 feet of gravel just below. Then comes 2 to 4 feet of hard-pan, succeeded by gravel which extends down at least 80 feet and probably much deeper.

One-half mile south of Angola a pit at the base of a knoll shows:

Section of Pit One-half Mile South of Angola.

	Feet.
1. Clay	4
2. Sand and gravel	6
3. Hard pan	4
4. Gravel	8

Further south, the sandy aspect of the surface gives place to clay, the influence of the Erie lobe beginning to affect the soil.

Just west of Angola, there is a pit which has yielded probably five or six thousand yards of gravel, and which is good for a great deal more. The section here shows:

Section of Pit Just West of Angola.

		Feet.
1.	Clay	4
2.	Sand and gravel	20
3.	Hard pan	2

At the cross roads two and a half miles west from Angola, the cut made in grading the road shows a vast amount of gravel, probably 100,000 yards being in sight. It is of good quality and can be worked with little expense. The gravel face is so great that the surface clay might be allowed to mix with the gravel without detriment to the value of the latter for road material.

Fox Lake, two miles southwest from Angola, is situated between clay knolls. There is practically no gravel in this immediate vicinity, wells being 50 to 75 feet deep before gravel is struck which yields enough water.

Hog-back Lake and Vicinity.

This lake takes its name from a great ridge skirting its northern and eastern shores. It is a typical kame, probably half a mile long, from 100 to 250 yards wide at the base, tapering to 10 to 20 yards at the top, and varying from 20 to 180 feet in height. It runs for half its length without any variation in level, and looks exactly like a railroad "fill" probably 80 feet high. The entire ridge is composed of gravel and boulders, and will furnish several hundreds of thousands of yards.

The dredge has lowered the lake and left a strip of old lake bottom from 20 to 80 yards wide composed of marl, peat or gravel. There is a great amount of fine washed gravel to be had here without stripping.

Area Northwest of Angola.

From this point west, across the county line, the hills are all gravel, capped sometimes with a heavy clay; but the gravel can be removed at the bases of the knolls with little expense for stripping.

In Mill Grove Township, in the northwestern corner of the county, practically every hill is a gravel bed, and the plain surfaces here are also gravel.

Going from Angola north to James Lake the road crosses the moraine, and exposes in four or five places the characteristic drift of this region. The clay is from 2 to 4 feet deep, underlain by 20+ feet of gravel. Along this five miles of road there are many thousands of yards of gravel exposed, and most of it is good in quality. Lake James itself is in a basin surrounded with gravel hills. The shores of the lake are in many places pure gravel. This whole region is abundantly supplied with good road material.

Area Northeast of Angola.

As one goes north from Angola toward Fremont the character of the drift changes gradually from predominant gravel and sand to predominant clay. At Fremont the surface soil is clay with small boulders—a typical till. The gravel bed is here twenty feet and more down. West from Fremont two miles, the clay thins out, and gravel appears. To the east, the clay thickens, and even the till-boulders are scarce. There are small pockets of gravel, seldom containing more than 1,000 yards, in the heavy till knolls, and these will probably prove sufficient for local use.

Area Southeast of Angola.

The southeastern corner of the county is occupied by the same morainal ridge that forms most of the surface of Dekalb County, and here also the clay makes at least 95 per cent. of the soil. There are some small gravel inclusions, but they are expensive to work. Between this corner and the great moraine belt there is a flat till plain, which is a mixture of gravel, sand and clay, the latter predominating. Gravel fit for road material is scarce here.

Fish Lake, in the southeast township, is surrounded by clay knobs for the most part, but there are a few gravel knolls, furnishing in the aggregate enough material for any roads that are likely to be improved in the vicinity.

The dredge ditch which traverses Pigeon River valley for 7 or 8 miles is for the most part through gravel. This gravel bed is the great sheet that underlies the hills, at depths of 40 to 150 feet. Here along the ditch the gravel is piled high on the banks, ready to be hauled away. There is no more favorable situation anywhere in Indiana for building gravel roads. The material

can not be excelled for quality; it is ready for use without stripping or lifting out of a pit; the course of the stream makes it accessible for a considerable area, and there is enough material here for fifty miles of road, at a conservative estimate.

Road sentiment is not strong in Steuben County. Some of the main roads are graveled, but considering the abundance and cheapness of material, this county must be classed as one of the poorest in Northern Indiana.

LAGRANGE COUNTY.

Area in square miles	393
Population in 1900	15,284
Miles of public roads	826
Miles of improved roads*	275
Percentage of roads improved	33.3
Miles improved with gravel	275
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$750
Total original cost of improved roads	$206,250
Authority	V. D. Weaver, County Auditor

*All the improved roads have been built by the farmers and the cost of $750 per mile is estimated.

This county, on the Michigan line, is just west from Steuben. Its topography falls into three general divisions. The southeastern third is of the knob-and-basin type, where the knobs are gravel, and the lowlands muck, marl or sand covered, with clay bottoms. The northern third of the county, and a narrow belt along the Little Elkhart River, are gravel plains made up of alluvial overwash from the morainal regions round about. The southwestern third is mainly marsh, where 2 to 5 feet of muck or sandy soil are underlain by fine gravel. This has been exposed only by the dredges, since ditching has been begun.

The northwest township, and a narrow belt bordering the Pigeon Creek valley, are sand areas, where gravel is seldom found in large quantities, but where enough local deposits can be found to fill all requirements.

Lagrange and Vicinity.

Lagrange lies in a region of very subdued morainal hills, the knolls being smoothed off and the basins well filled. The soil is sandy, and in places loamy. The knolls are clay or till-capped, with gravel bases. The city gravel pit, one-half mile south of town, and Morrison's pit a mile southwest, are fair specimens. The section in the latter shows:

Section of Morrison Pit.

		Feet.
1.	Clay	1
2.	Coarse bouldery gravel	4
3.	Fine-grained gravel	2
4.	Sand	2

In the city pit, the section is similar, except that sand is more abundant. In most of this region south of town, the soil for a depth of 40 feet is sand or gravel. There is easily enough gravel in this region to do all necessary road-work, if small deposits will be utilized, and if care is taken to keep out the sand.

Area Southwest of Lagrange.

After one gets some three miles south and west from Lagrange, the character of the county becomes marshy, with ridges standing above the flats. The ridges are sandy, with occasional bouldery streaks, and some small gravel beds, usually less than 500 yards in size.

Five miles southwest of Lagrange and one and a half miles west of Lake Oliver is the Duncan pit—a mere scratch in an enormous kame. This ridge extends for a mile and a half east and west, varies from 20 to 75 feet in height and from 40 to 150 yards in width at the base. It is practically entirely gravel—the percentage of sand and clay being so slight as to be a negligible quantity. The marsh and low ground on each side are also underlain with 10 to 20 feet of gravel—probably washed material from the kame. From this pit there have been built twelve miles of road, by land tax methods. The gravel packs excellently and makes an exceptionally good road. The country within hauling distance will save money in the end by abandoning the use of sandy gravel and obtaining their supplies

from here. The very lowest estimate for this one ridge would be a million cubic yards, and there is probably twice that much available.

Area North of Lagrange.

A section of a ditch bank one mile north of Lagrange shows:

		Feet.
1.	Soil (sandy till)	2
2.	Gravel and sand	5

The Bloomfield Township pit is $2\frac{1}{2}$ miles northeast from Lagrange. It is a fine bank, showing 12 to 16 feet of good gravel under 2 to 4 feet of clay. In all this area north from Lagrange to Pigeon River, the surface is distinctly sandy or gravelly. The ridges are all capped with clay or hard-pan, and nearly all have gravel at the base. There is no difficulty here about finding gravel, but it is usually pretty well mixed with sand, and should be screened before using. Some of the roads here are built of a mixture of gravel, quicksand and hard-pan. It packs in a year and makes an excellent road. Where careful grading has been done, the material lasts a long while, longer than the sandy gravel that is sometimes used in this vicinity.

Pigeon River Valley.

Here, as in Steuben County, the valley of Pigeon River is a gravel plain extending almost the length of the county. Here, however, the humus is 4 to 6 feet deep, and there is no dredge ditch to reveal the gravel. There is an abundance of it below the soil, but too deep for ordinary methods of work. A steam scoop might be used to advantage. The prairie north of the valley is also underlain with gravel, and the little knolls scattered about in it will furnish enough material for most of the roads.

Area in Northwestern Part of the County.

In the extreme northwestern corner of the county there is a group of morainal knolls, some sharply defined, others rounded. The latter are of clay, the former of gravel; these will furnish enough road material for this vicinity.

The trolley line from Lagrange to Shipshewana cuts down in many places through 2 to 6 feet of clay and reveals 4 to 8

feet of good gravel below. Excellent gravel beds occur here from 1 to 2 miles apart. In the vicinity of Shipshewana gravel is very scarce. There are three small pits 2 miles southwest from the village, containing a poor gravel. North from the town there is a sand plain, where gravel is not to be had.

Wolcottville and Vicinity.

This vicinity is a till plain, with ridges of low relief standing out from the low lands. Surface indications everywhere point to till or hard-pan.

The Wabash Railroad has an enormous gravel pit in one of the ridges about a mile east of Wolcottville. The pit occurs in a ridge whose top and sides are till. The gravel bed was accidentally discovered in making a cut while building the road bed; and fortunately, too, for there is absolutely no surface sign of gravel. The section shows:

Section of Wabash Railway Pit.

	Feet.
1. Till and yellow clay	6-12
2. Gravel, interbedded with sand	18-30

It is said that this pit is about to be abandoned on account of the heavy stripping. If so, there are thousands of yards of good gravel left in the bottom of the pit that might be used for road improvement. About 40 acres are covered to a depth of three feet with gravel which can be had without stripping or any expense other than shoveling into wagons.

On the other side of the same ridge, the G. R. & I. Railway is opening a new pit. It is apparently in the same gravel bed as the other. The township has a small pit in this same deposit.

About 4 miles southwest from Wolcottville is the "Hog-back," a kame consisting mainly of gravel and sand. This ridge will yield a great deal of good road material, with careful working.

West from Wolcottville about 2 miles the "Haw-patch" begins—a plain covered with loamy and gravelly soil. There are some low till ridges standing out from the plain. At depths of 4 to 10 feet gravel occurs, extending down 10 to 25 feet. It is sandy and not good road material. All the road work in this vicinity has been done with gravel hauled by the Wabash Railway from their pit described above.

West from Lagrange the surface is clay with practically no gravel in workable distance. The valley of the Little Elkhart is a gravel plain, where a fair road material occurs under 4 to 6 feet of loam. The main difficulty in working gravel here is water. A pump or dredge could, however, be used to overcome this.

Road sentiment is not very strong in Lagrange County. It seems certain that only a few localities are more than three miles from good gravel. If the small pits were developed and worked, perhaps 75 per cent. of the roads could be built within three miles. The fact that the natural surface of the roads makes a fair road-bed probably accounts for the slowness to gravel improvement shown here; but with good gravel so easily obtained it seems that more really modern roads should be built.

ELKHART COUNTY.

Area in square miles	465
Population in 1900	45,052
Miles of public roads	580
Miles of improved roads	312
Percentage of roads improved	53.8
Miles improved with gravel	312
Miles improved with crushed stone	None
Average original cost of gravel roads per mile*	$800
Total original cost of improved roads	$249,600
Annual cost of repairs per mile on gravel roads 5 years old	$60
Miles of improved roads (gravel) built in 1905	30
Proportion of improved roads built since 1895	50%
Satisfaction of farmers with investment in improved roads—	"Possibly a majority are well satisfied."
Authority	John L. Cooper, County Surveyor

*All improved roads have been built by the township.

This county, situated on the Michigan line, has at least half its surface occupied by gravel or sand plains. The most extensive is that of the St. Joseph River, continuous with Pigeon River Valley. Tributary to this plain is the valley of Elkhart River, a narrow strip. A little further west, and separated from the Elkhart Valley by a belt of morainal ridges, is the great till and gravel plain extending southwest into Kosciusko and Marshall counties.

Entering the county from the east is a lobe of the Saginaw moraine which makes one-third of the area of the county and is responsible for most of the rough land. It likewise is about all the clay land in the county.

Good gravel is very scarce in Elkhart County. Leverett calls the river valleys "gravel plains," but "quicksand" would be a better term. The Elkhart River valley has the following section, generalized from at least twenty different trials:

General Section of Elkhart River Valley.

		Feet.
1.	Black sand	7-9
2.	Blue till	2
3.	Coarse gravel	6

It is evident that the coarse gravel is not available, and the quicksand is not at all fit for road material. The edge of the valley is bordered by a low bluff, 8 to 10 feet high. This is mainly till, although a sandy or gravelly clay sometimes occurs at the base. This gravel is about 60 per cent. sand, 20 per cent. gravel and 20 per cent. clay. It is not at all fit for road use, unless it be screened, although it is quite extensively used. Roads built from it were in June 6 inches deep in dust, and the chuck-holes of the winter were still in evidence.

Vicinity of Goshen.

West from Goshen about three miles, the morainal ridges begin. These are composed of a number of knolls, clay covered to a depth of 4 or 5 feet, with sand or gravel bases. A fine pit, which will probably run 15,000 yards, just three miles west of Goshen, has the following section:

		Feet
1.	Clay	3
2.	Sand and gravel	6

There is too much sand for a first quality gravel, and a good deal of clay is allowed to fall into the material while it is being worked. It makes a fair road, but wears out too rapidly. Nearly every ridge contains as good gravel as this one, but none of them are worked until one gets 3 miles west. Here in Harrison Township there are several pits being used, all furnishing a fair gravel with little stripping. They are all pretty sandy, but make good roads.

At Dunlap, five miles northwest of Goshen, the surface of the Elkhart Valley for a radius of 2 miles is a hard clay, about 4

feet thick. Underneath this there is found a gravel stratum which extends at least 20 feet and probably more. In practice, very little of the clay is removed, and the mixture of clay and gravel does not seem to work well. There is enough clear gravel to warrant stripping off all the clay, and it will make a good road.

Middlebury and the Morainal Tract.

Middlebury lies in a plain which nestles between two huge morainal regions. These rise above all the other knolls, standing probably 125 feet above the plain. Their structure is very complex, the cuts in some places showing till, in others sand, and still others gravel. The following section generalized from about twenty wells and cuts, shows:

General Section of Morainal Ridges near Middlebury.

	Feet.
1. Gravel	20 to 40
2. Hard pan	6 to 16
3. Sand and gravel	30
4. Blue till	4
5. Bouldery gravel	20

Some sections can be found where almost all the gravel is replaced by till or clay. But as a rule one needs not go more than a hundred yards along the edge of the hill without finding an abundance of good gravel, with a light stripping, seldom going over four feet.

In Middlebury the large pit shows 12 feet of good gravel under 4 feet of clay, and there are numerous other pits and sections in the vicinity showing the same sequence. There is no practicable limit to the quantity of gravel in these ridges. It is certain that enough can be found to gravel every road within hauling distance, and make the merest scratch in the supply. This gravel stratum is revealed in the cuts along the railway from Middlebury to Goshen for a distance of four or five miles. It constantly grows sandier, however, and at the junction of the moraine with the Elkhart Valley the gravel has about disappeared. The outermost knolls are sand, with a clay cap. The outwash from these knolls has probably formed the sand plain of the Elkhart Valley.

Area South of Goshen.

South from Goshen to New Paris the road leads through the sandy flats of the Elkhart River. This is all sand except an occasional knoll which contains some gravel. At New Paris, the morainal ridges appear just east of the village, and as usual they contain much gravel under clay. There are several pits in these ridges, all showing an excellent gravel. There is more than enough to supply any possible demand.

In the extreme southern part of the county the dredge ditches have got down into an excellent gray water gravel and thrown out a lot of it on the banks. This is easily accessible and good material.

Vicinity of Elkhart.

Elkhart lies in the sandy plain of the Elkhart River. There is no workable gravel deposit within reaching distance, the sand running 6 to 10 feet deep. The bluffs at the edge of the valley show some gravel, but it is sandy. Under the sand there is plenty of good gravel in many places, but a scoop will be necessary to get it out.

There are 312 miles of improved road in the county, all built of gravel, under the land tax system. The gravel roads about Middlebury and New Paris are good, but most of the others are built in slovenly style, with poor material.

ST. JOSEPH COUNTY.

Area in square miles	560
Population in 1900	58,881
Miles of public roads	870.7
Miles of improved roads*	238.7
Percentage of roads improved	27.4
Miles improved with gravel	238.7
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$750
Total original cost of improved roads	$179,025
Authority	A. J. Hammond, City Engineer of South Bend

*"No roads have been built in this county under the gravel road law pertaining to specal assessments. The separate townships provide a road tax which is used by the trustee to open roads, build dirt roads and gravel certain roads. and a small mileage in each township is presumed to be graveled each year.

"The accounts of the trustees will not show, without an extended search by

This county, with South Bend as its capital, is on the Michigan line. At least half its area is gravel plain. Almost all the northwestern half of the county is a gravel area, formed from the outwash of the Valparaiso and Maxinkuckee moraine. The St. Joseph River occupies an extensive gravel area. In the southeast corner is a till-plain which contains more or less gravel under the till. The moraine here is the northern end of the Maxinkuckee lobe.

The general characterization of the county is that of gravel and sand. The valley of the St. Joseph River is a gravel plain, the first bottom, comprising the deposits on the inner side of the bends, being, as a rule, sand. The second bottom, which is 8 or 10 feet above the first, has a surface cover of red clay and sand 2 to 6 feet deep. Below this, gravel pockets of enormous size are found, and everywhere there is a gravel stratum underneath.

Vicinity of Mishawaka.

One of the characteristic gravel pockets is at Twin Branch, three miles east of Mishawaka, where the Lake Shore owns a pit. There are hundreds of thousands of yards of excellent grey water gravel here, which will build good roads, if a little of the clay is added to aid in packing.

Just in the edge of Mishawaka, in the river bluff, there is an exposure of gravel indicating at least 50,000 yards of good material. The stripping is practically nothing, since the surface material is necessary to good road-stuff. Another pocket, equally good but smaller, is in the heart of the city, two blocks from the postoffice. Every excavation in Mishawaka which is 4 to 6 feet deep gets through the red sand into the gravel. This statement holds good for the entire valley, as far as observation and trials showed.

On the south side of the valley, along the hills of the Maxin-

an accountant, how much of the road tax goes to maintenance and how much to new roads, etc.

"The trustee of Portage township, where South Bend is located, tells me that he has about $6,000 a year for repairs on roads, new roads, etc., and that he builds or rather puts gravel on about three or four miles of road per year. If the other townships do as well there should be some 40 miles of road graveled per year. Those graveled last year cost about $500 per mile, as near as the trustee could tell, but there was little grading and the gravel was close to the road. The cost of $750 per mile is therefore estimated.

"There is not much interest taken in this work, as in the central part of the State, and yet I suppose the farmers are well satisfied with the system."—A. J. H.

Going from Angola north to James Lake the road crosses the moraine, and exposes in four or five places the characteristic drift of this region. The clay is from 2 to 4 feet deep, underlain by 20+ feet of gravel. Along this five miles of road there are many thousands of yards of gravel exposed, and most of it is good in quality. Lake James itself is in a basin surrounded with gravel hills. The shores of the lake are in many places pure gravel. This whole region is abundantly supplied with good road material.

Area Northeast of Angola.

As one goes north from Angola toward Fremont the character of the drift changes gradually from predominant gravel and sand to predominant clay. At Fremont the surface soil is clay with small boulders—a typical till. The gravel bed is here twenty feet and more down. West from Fremont two miles, the clay thins out, and gravel appears. To the east, the clay thickens, and even the till-boulders are scarce. There are small pockets of gravel, seldom containing more than 1,000 yards, in the heavy till knolls, and these will probably prove sufficient for local use.

Area Southeast of Angola.

The southeastern corner of the county is occupied by the same morainal ridge that forms most of the surface of Dekalb County, and here also the clay makes at least 95 per cent. of the soil. There are some small gravel inclusions, but they are expensive to work. Between this corner and the great moraine belt there is a flat till plain, which is a mixture of gravel, sand and clay, the latter predominating. Gravel fit for road material is scarce here.

Fish Lake, in the southeast township, is surrounded by clay knobs for the most part, but there are a few gravel knolls, furnishing in the aggregate enough material for any roads that are likely to be improved in the vicinity.

The dredge ditch which traverses Pigeon River valley for 7 or 8 miles is for the most part through gravel. This gravel bed is the great sheet that underlies the hills, at depths of 40 to 150 feet. Here along the ditch the gravel is piled high on the banks, ready to be hauled away. There is no more favorable situation anywhere in Indiana for building gravel roads. The material

can not be excelled for quality; it is ready for use without stripping or lifting out of a pit; the course of the stream makes it accessible for a considerable area, and there is enough material here for fifty miles of road, at a conservative estimate.

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LAGRANGE COUNTY.

Area in square miles	393
Population in 1900	15,284
Miles of public roads	826
Miles of improved roads*	275
Percentage of roads improved	33.3
Miles improved with gravel	275
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$750
Total original cost of improved roads	$206,250
Authority	V. D. Weaver, County Auditor

*All the improved roads have been built by the farmers and the cost of $750 per mile is estimated.

This county, on the Michigan line, is just west from Steuben. Its topography falls into three general divisions. The southeastern third is of the knob-and-basin type, where the knobs are gravel, and the lowlands muck, marl or sand covered, with clay bottoms. The northern third of the county, and a narrow belt along the Little Elkhart River, are gravel plains made up of alluvial overwash from the morainal regions round about. The southwestern third is mainly marsh, where 2 to 5 feet of muck or sandy soil are underlain by fine gravel. This has been exposed only by the dredges, since ditching has been begun.

The northwest township, and a narrow belt bordering the Pigeon Creek valley, are sand areas, where gravel is seldom found in large quantities, but where enough local deposits can be found to fill all requirements.

Lagrange and Vicinity.

Lagrange lies in a region of very subdued morainal hills, the knolls being smoothed off and the basins well filled. The soil is sandy, and in places loamy. The knolls are clay or till-capped, with gravel bases. The city gravel pit, one-half mile south of town, and Morrison's pit a mile southwest, are fair specimens. The section in the latter shows:

Section of Morrison Pit.

		Feet.
1.	Clay	1
2.	Coarse bouldery gravel	4
3.	Fine-grained gravel	2
4.	Sand	2

In the city pit, the section is similar, except that sand is more abundant. In most of this region south of town, the soil for a depth of 40 feet is sand or gravel. There is easily enough gravel in this region to do all necessary road-work, if small deposits will be utilized, and if care is taken to keep out the sand.

Area Southwest of Lagrange.

After one gets some three miles south and west from Lagrange, the character of the county becomes marshy, with ridges standing above the flats. The ridges are sandy, with occasional bouldery streaks, and some small gravel beds, usually less than 500 yards in size.

Five miles southwest of Lagrange and one and a half miles west of Lake Oliver is the Duncan pit—a mere scratch in an enormous kame. This ridge extends for a mile and a half east and west, varies from 20 to 75 feet in height and from 40 to 150 yards in width at the base. It is practically entirely gravel—the percentage of sand and clay being so slight as to be a negligible quantity. The marsh and low ground on each side are also underlain with 10 to 20 feet of gravel—probably washed material from the kame. From this pit there have been built twelve miles of road, by land tax methods. The gravel packs excellently and makes an exceptionally good road. The country within hauling distance will save money in the end by abandoning the use of sandy gravel and obtaining their supplies

from here. The very lowest estimate for this one ridge would be a million cubic yards, and there is probably twice that much available.

Area North of Lagrange.

A section of a ditch bank one mile north of Lagrange shows:

	Feet.
1. Soil (sandy till)	2
2. Gravel and sand	5

The Bloomfield Township pit is $2\frac{1}{2}$ miles northeast from Lagrange. It is a fine bank, showing 12 to 16 feet of good gravel under 2 to 4 feet of clay. In all this area north from Lagrange to Pigeon River, the surface is distinctly sandy or gravelly. The ridges are all capped with clay or hard-pan, and nearly all have gravel at the base. There is no difficulty here about finding gravel, but it is usually pretty well mixed with sand, and should be screened before using. Some of the roads here are built of a mixture of gravel, quicksand and hard-pan. It packs in a year and makes an excellent road. Where careful grading has been done, the material lasts a long while, longer than the sandy gravel that is sometimes used in this vicinity.

Pigeon River Valley.

Here, as in Steuben County, the valley of Pigeon River is a gravel plain extending almost the length of the county. Here, however, the humus is 4 to 6 feet deep, and there is no dredge ditch to reveal the gravel. There is an abundance of it below the soil, but too deep for ordinary methods of work. A steam scoop might be used to advantage. The prairie north of the valley is also underlain with gravel, and the little knolls scattered about in it will furnish enough material for most of the roads.

Area in Northwestern Part of the County.

In the extreme northwestern corner of the county there is a group of morainal knolls, some sharply defined, others rounded. The latter are of clay, the former of gravel; these will furnish enough road material for this vicinity.

The trolley line from Lagrange to Shipshewana cuts down in many places through 2 to 6 feet of clay and reveals 4 to 8

feet of good gravel below. Excellent gravel beds occur here from 1 to 2 miles apart. In the vicinity of Shipshewana gravel is very scarce. There are three small pits 2 miles southwest from the village, containing a poor gravel. North from the town there is a sand plain, where gravel is not to be had.

Wolcottville and Vicinity.

This vicinity is a till plain, with ridges of low relief standing out from the low lands. Surface indications everywhere point to till or hard-pan.

The Wabash Railroad has an enormous gravel pit in one of the ridges about a mile east of Wolcottville. The pit occurs in a ridge whose top and sides are till. The gravel bed was accidentally discovered in making a cut while building the road bed; and fortunately, too, for there is absolutely no surface sign of gravel. The section shows:

Section of Wabash Railway Pit.

		Feet.
1.	Till and yellow clay	6-12
2.	Gravel, interbedded with sand	18-30

It is said that this pit is about to be abandoned on account of the heavy stripping. If so, there are thousands of yards of good gravel left in the bottom of the pit that might be used for road improvement. About 40 acres are covered to a depth of three feet with gravel which can be had without stripping or any expense other than shoveling into wagons.

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West from Lagrange the surface is clay with practically no gravel in workable distance. The valley of the Little Elkhart is a gravel plain, where a fair road material occurs under 4 to 6 feet of loam. The main difficulty in working gravel here is water. A pump or dredge could, however, be used to overcome this.

Road sentiment is not very strong in Lagrange County. It seems certain that only a few localities are more than three miles from good gravel. If the small pits were developed and worked, perhaps 75 per cent. of the roads could be built within three miles. The fact that the natural surface of the roads makes a fair road-bed probably accounts for the slowness to gravel improvement shown here; but with good gravel so easily obtained it seems that more really modern roads should be built.

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*All improved roads have been built by the township.

This county, situated on the Michigan line, has at least half its surface occupied by gravel or sand plains. The most extensive is that of the St. Joseph River, continuous with Pigeon River Valley. Tributary to this plain is the valley of Elkhart River, a narrow strip. A little further west, and separated from the Elkhart Valley by a belt of morainal ridges, is the great till and gravel plain extending southwest into Kosciusko and Marshall counties.

Entering the county from the east is a lobe of the Saginaw moraine which makes one-third of the area of the county and is responsible for most of the rough land. It likewise is about all the clay land in the county.

Good gravel is very scarce in Elkhart County. Leverett calls the river valleys "gravel plains," but "quicksand" would be a better term. The Elkhart River valley has the following section, generalized from at least twenty different trials:

General Section of Elkhart River Valley.

		Feet.
1.	Black sand	7-9
2.	Blue till	2
3.	Coarse gravel	6

It is evident that the coarse gravel is not available, and the quicksand is not at all fit for road material. The edge of the valley is bordered by a low bluff, 8 to 10 feet high. This is mainly till, although a sandy or gravelly clay sometimes occurs at the base. This gravel is about 60 per cent. sand, 20 per cent. gravel and 20 per cent. clay. It is not at all fit for road use, unless it be screened, although it is quite extensively used. Roads built from it were in June 6 inches deep in dust, and the chuck-holes of the winter were still in evidence.

Vicinity of Goshen.

West from Goshen about three miles, the morainal ridges begin. These are composed of a number of knolls, clay covered to a depth of 4 or 5 feet, with sand or gravel bases. A fine pit, which will probably run 15,000 yards, just three miles west of Goshen, has the following section:

		Feet
1.	Clay	3
2.	Sand and gravel	6

There is too much sand for a first quality gravel, and a good deal of clay is allowed to fall into the material while it is being worked. It makes a fair road, but wears out too rapidly. Nearly every ridge contains as good gravel as this one, but none of them are worked until one gets 3 miles west. Here in Harrison Township there are several pits being used, all furnishing a fair gravel with little stripping. They are all pretty sandy, but make good roads.

At Dunlap, five miles northwest of Goshen, the surface of the Elkhart Valley for a radius of 2 miles is a hard clay, about 4

feet thick. Underneath this there is found a gravel stratum which extends at least 20 feet and probably more. In practice, very little of the clay is removed, and the mixture of clay and gravel does not seem to work well. There is enough clear gravel to warrant stripping off all the clay, and it will make a good road.

Middlebury and the Morainal Tract.

Middlebury lies in a plain which nestles between two huge morainal regions. These rise above all the other knolls, standing probably 125 feet above the plain. Their structure is very complex, the cuts in some places showing till, in others sand, and still others gravel. The following section generalized from about twenty wells and cuts, shows:

General Section of Morainal Ridges near Middlebury.

		Feet.
1.	Gravel	20 to 40
2.	Hard pan	6 to 16
3.	Sand and gravel	30
4.	Blue till	4
5.	Bouldery gravel	20

Some sections can be found where almost all the gravel is replaced by till or clay. But as a rule one needs not go more than a hundred yards along the edge of the hill without finding an abundance of good gravel, with a light stripping, seldom going over four feet.

In Middlebury the large pit shows 12 feet of good gravel under 4 feet of clay, and there are numerous other pits and sections in the vicinity showing the same sequence. There is no practicable limit to the quantity of gravel in these ridges. It is certain that enough can be found to gravel every road within hauling distance, and make the merest scratch in the supply. This gravel stratum is revealed in the cuts along the railway from Middlebury to Goshen for a distance of four or five miles. It constantly grows sandier, however, and at the junction of the moraine with the Elkhart Valley the gravel has about disappeared. The outermost knolls are sand, with a clay cap. The outwash from these knolls has probably formed the sand plain of the Elkhart Valley.

Area South of Goshen.

South from Goshen to New Paris the road leads through the sandy flats of the Elkhart River. This is all sand except an occasional knoll which contains some gravel. At New Paris, the morainal ridges appear just east of the village, and as usual they contain much gravel under clay. There are several pits in these ridges, all showing an excellent gravel. There is more than enough to supply any possible demand.

In the extreme southern part of the county the dredge ditches have got down into an excellent gray water gravel and thrown out a lot of it on the banks. This is easily accessible and good material.

Vicinity of Elkhart.

Elkhart lies in the sandy plain of the Elkhart River. There is no workable gravel deposit within reaching distance, the sand running 6 to 10 feet deep. The bluffs at the edge of the valley show some gravel, but it is sandy. Under the sand there is plenty of good gravel in many places, but a scoop will be necessary to get it out.

There are 312 miles of improved road in the county, all built of gravel, under the land tax system. The gravel roads about Middlebury and New Paris are good, but most of the others are built in slovenly style, with poor material.

ST. JOSEPH COUNTY.

Area in square miles	560
Population in 1900	58,881
Miles of public roads	870.7
Miles of improved roads*	238.7
Percentage of roads improved	27.4
Miles improved with gravel	238.7
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$750
Total original cost of improved roads	$179,025
Authority	A. J. Hammond, City Engineer of South Bend

*"No roads have been built in this county under the gravel road law pertaining to specal assessments. The separate townships provide a road tax which is used by the trustee to open roads, build dirt roads and gravel certain roads. and a small mileage in each township is presumed to be graveled each year.

"The accounts of the trustees will not show, without an extended search by

This county, with South Bend as its capital, is on the Michigan line. At least half its area is gravel plain. Almost all the northwestern half of the county is a gravel area, formed from the outwash of the Valparaiso and Maxinkuckee moraine. The St. Joseph River occupies an extensive gravel area. In the southeast corner is a till-plain which contains more or less gravel under the till. The moraine here is the northern end of the Maxinkuckee lobe.

The general characterization of the county is that of gravel and sand. The valley of the St. Joseph River is a gravel plain, the first bottom, comprising the deposits on the inner side of the bends, being, as a rule, sand. The second bottom, which is 8 or 10 feet above the first, has a surface cover of red clay and sand 2 to 6 feet deep. Below this, gravel pockets of enormous size are found, and everywhere there is a gravel stratum underneath.

Vicinity of Mishawaka.

One of the characteristic gravel pockets is at Twin Branch, three miles east of Mishawaka, where the Lake Shore owns a pit. There are hundreds of thousands of yards of excellent grey water gravel here, which will build good roads, if a little of the clay is added to aid in packing.

Just in the edge of Mishawaka, in the river bluff, there is an exposure of gravel indicating at least 50,000 yards of good material. The stripping is practically nothing, since the surface material is necessary to good road-stuff. Another pocket, equally good but smaller, is in the heart of the city, two blocks from the postoffice. Every excavation in Mishawaka which is 4 to 6 feet deep gets through the red sand into the gravel. This statement holds good for the entire valley, as far as observation and trials showed.

On the south side of the valley, along the hills of the Maxin-

an accountant, how much of the road tax goes to maintenance and how much to new roads, etc.

"The trustee of Portage township, where South Bend is located, tells me that he has about $6,000 a year for repairs on roads, new roads, etc., and that he builds or rather puts gravel on about three or four miles of road per year. If the other townships do as well there should be some 40 miles of road graveled per year. Those graveled last year cost about $500 per mile, as near as the trustee could tell, but there was little grading and the gravel was close to the road. The cost of $750 per mile is therefore estimated.

"There is not much interest taken in this work, as in the central part of the State, and yet I suppose the farmers are well satisfied with the system."—A. J. H.

kuckee moraine the outwash is spread, delta-fashion, over the bottom for a distance of 200 to 400 yards, and adds 2 to 10 feet of sand to the top covering. At such places, the gravel is found 4 to 12 feet down. This valley contains gravel enough for the entire county. There is no reason why it should not be used upon all roads within hauling distance.

Southern Portion of County.

South from Mishawaka and South Bend the morainal hills occupy a strip running to the south line of the county and 6 to 8 miles wide. The hills are mainly clay and till, with some sand and gravel seams, and a heavy gravel at the bottom. The usual depth of the wells is 100 to 150 feet, when the great gravel stratum is reached. The section of a well being drilled about three miles south of Mishawaka showed:

Section of Well Three Miles South of Mishawaka.

		Feet.
1.	Sand	10
2.	Hard pan and sand	5
3.	Clay	10
4.	Sand and gravel	40
5.	Clay	60
6.	Gravel (water bearing)	5

There is no way to predict anything about this region except that gravel is very scarce. In 20 square miles here, there is not a single pit. The road on the crest of the moraine varies in nature. Stretches of sandy material are followed by stretches of clay and hard-pan. The latter, when well graded, makes a pretty good road of itself. There are half-mile lengths of it here as good as most gravel roads. The methods of D. Ward King would make elegant roads with this material to work upon, and with a solid bed, gravel could be profitably hauled from the valley for five or six miles and used as a top dressing.

The differences in the same glacial formation within comparatively short distances is obvious here in this Maxinkuckee moraine. At Rochester the typical section is:

		Feet.
1.	Clay	4—8
2.	Gravel	20—60

Here the typical section will show:

		Feet.
1.	Clay or hard pan	20—60
2.	Sand or gravel	10—20

with more clay beneath.

Walkerton and Vicinity.

The best pit seen in northwestern Indiana for road material is at Walkerton. The quantity is practically unlimited, and the stripping is light. The upper four or six feet of the gravel is red in color, due to the presence of 20 per cent. of red clay. This is the gravel preferred hereabouts for road use on account of its quick packing. Under the red gravel is a layer 10 to 15 feet deep of pure gray material, fine grained and ideal road-stuff, when mixed with a little clay to insure packing. A mixture of this and the red clay ought to make an excellent road, since it would pack well and wear a long time.

The pit is owned by Starke County people, who this year (1905) are building 21 miles of road from it, and it is thought that another 20 miles will be built of this gravel in 1906.

North Liberty and Vicinity.

North Liberty is in the middle of a gravel plain composed of the overwash from the moraine out towards the Kankakee river. The plain is sandy on the top, with a fair quality of gravel almost everywhere underneath. Almost any excavation four feet or more in depth reveals this gravel, and there is clay enough in it to pack it hard in a year.

The Three I Railway has a large pit in this gravel plain, about 7 miles north of North Liberty. There are thousands of yards of good gravel here.

At a number of places in this vicinity pits are in operation, any one of which would, if developed, furnish enough material to build all the roads within hauling distance. It is certain that this entire gravel plain can build its roads with good gravel and not haul more than two miles.

Lakeville and Vicinity.

At Lakeville, in the Maxinkuckee moraine, there is no gravel. The railway cuts here show 20-25 feet of yellow clay. At the village, there is a sand-pit, from which some poor material has been taken and used on the roads. This section can be graveled without excessive hauling by opening pits in the plain just beyond the moraine. In many cases, the material will have to be hauled 4 or 5 miles, but it is worth putting down after it is obtained.

All of the principal roads in the county are graveled, and some of the side roads. What is needed is some systematic work—the establishing of grades, the more careful selection of materials, and thorough superintendence of the work. With such an abundance of good building material, this county should have as good roads as any in the State, and it lacks much, as yet, of reaching this position.

The following table showing the miles of public and improved roads in the county, by townships, was prepared by one of the assistants in the office of A. J. Hammond, City Engineer of South Bend:

Tabulation of Roads in St. Joseph County.

Township.	*Miles of Public Road.*	*Miles of Gravel Road.*
Center	40	19
Clay	46.5	19
German	38.66	17
Greene	61	16
Harris	48.5	15
Liberty	86	27
Lincoln	48	20.66
Madison	103	8
Olive	93.5	25
Penn	141	33
Portage	28	14
Union	82	8
Warren	54.5	17
Totals	870.66	238.66

LAPORTE COUNTY.

Area in square miles	563
Population in 1900	38,386
Miles of public roads	1,200
Miles of improved roads	89
Percentage of roads improved	7.4

Miles improved with gravel	None
Miles improved with crushed stone	89
Average original cost of stone roads per mile	$4,000
Total original cost of improved roads	$356,000
Miles of improved roads (stone) built in 1905	16
Miles of improved roads (stone) contracted for 1906	3.5
First improved roads built	1901
Satisfaction of farmers with investment in improved roads	Good
Authority	L. E. Daniels

This county, in the northwestern portion of the State, has three distinct topographic belts. A narrow strip along Lake Michigan is mainly sand, with a very occasional clay knoll; next to this comes a morainic belt extending across the county in a northeast-southwest direction. The upland district is clay in the main, with sand in the bases of the knolls. There are some little gravel lenses down in the clay 25-30 feet, in which many of the wells find water. Between the moraine and the Kankakee there is a sand plain made up of overwash from the moraine. There is very little gravel here, at no place nearly enough to make a workable pit. There is not a township in the county that has enough gravel for road purposes. This condition has been recognized, and macadam has been placed in the main roads. A very fine stone road extends from Laporte to Michigan City, and there are other shorter roads.

PORTER COUNTY.

Area in square miles	418
Population in 1900	19,175
Miles of public roads	1,000
Miles of improved roads	110
Percentage of roads improved	10.1
Miles improved with gravel	91
Miles improved with crushed stone	19
Average original cost of gravel roads per mile*	$3,150
Average original cost of stone roads per mile	$3,100
Total original cost of improved roads	$345,000
Annual cost per mile for repairs on gravel roads 5 yeas old	$45
Annual cost of repairs per mile on stone roads 5 years old	$30
First improved roads built	1897
Satisfaction of farmers with investment in improved roads	Good
Authority	S. P. Corboy, County Auditor

*"Most of the roads of this county were put in several years ago when labor and material was much cheaper than now. We have about 15 miles under way and it will cost about $5,000 per mile, according to the report of the viewers. This is not all due to increase in supplies, etc., but the demand is for better roads, and the specifications have been made much stronger.

"The majority of the farmers in the county are very much in favor of our system of gravel roads, especially in Union, Center, Portage, Westchester and Boone townships. Some of the other townships have no gravel roads as yet." S. P. C.

This county lies just west of Laporte County and south of Lake Michigan, in the northwestern portion of the State. Three distinct topographic belts or regions, each with well marked characteristics, comprises its surface. The northern one of these, comprising about 70 square miles, is composed mainly of sand, thrown up either in hills or dunes, some of which approximate 200 feet in height, or in low ridges, usually six to 15 feet above the level of the marshes which lie between them.

The middle or morainic belt is about 15 miles in width, and comprises about 200 square miles of the area of the county. The third region of belt of the county is marsh land in the valley of the Kankakee basin. This area comprises about 105 square miles, a large part of which is rich, well drained prairie lands, the remainder being overflowed each year by the Kankakee.

The crest of the morainic belt rises from 840 to 888 feet above Lake Michigan. It enters the county from the west near the center, and passes in a northeasterly direction to a point some five miles north of Valparaiso. Thence it runs eastward to the county line, at which point the moraine is but about seven miles in width. In general it is made up of alternate layers of yellowish clay and sand, which range from 12 to 20 feet in thickness.

But little, if any, gravel suitable for road purposes has been found in the county, though careful investigation may reveal some deposits in the higher ridges north and west of Hebron. Several small deposits have been found just south and west of Valparaiso, one of which, called "Sugar Loaf," 20 feet in height and covering half an acre, was used on the streets of that city. A deposit three feet and more in thickness was noted east of Bell Marsh on the side of the Valparaiso and Laporte road, in the southeast quarter of section 10 (35 N., 5 W.). The appearance of the surrounding country is very favorable to the discovery of gravel deposits in this vicinity, though careful search has, as yet, revealed none.

The gravel or stone used on the 110 miles of improved roads of the county has all been imported from Illinois. For that reason the cost of the roads is much higher than in those counties to the east and south where material is found close to the roads where it was used. Not an outcrop of rock of any kind occurs in the county.

LAKE COUNTY.

Area in square miles	465
Population in 1900	37,892
Miles of public roads	700
Miles of improved roads	158.06
Percentage of roads improved	22.5
Miles improved with gravel	71.16
Miles improved with crushed stone	86.90
Average original cost of gravel roads per mile	$3,013
Average original cost of stone roads per mile	$4,330
Total original cost of improved roads	$590,753
Annual cost of repairs per mile on gravel roads 5 years old	$50
Annual cost of repairs per mile on stone roads 5 years old	$95
Miles of improved roads (stone) built in 1905	3
First improved roads built	1896
Satisfaction of farmers with investment in improved roads	Good
Authorities	W. L. Allman, Co. Auditor; W. F. Bridge, Co. Surveyor

This county occupies the extreme northwestern corner of Indiana, and is bounded on the south by the Kankakee River, on the north by Lake Michigan and on the west by Illinois. The topographic belts are of the same nature as those found in Porter County, and consist of a sandy northern, a middle morainic and a southern marshy region. The northern region of the county comprises about 143 square miles, the most of which is covered with rather low, parallel sand ridges with numerous marshy depressions or sags intervening. In the northeastern corner, about Millers, are a number of very high sand dunes.

The middle or morainic region is covered by a sheet of drift which, at Crown Point, the county seat, is 141 feet in thickness. Where this moraine crosses the State line and enters Lake County, it is about 17 miles in width. Its soil in many places in its northern portion immediately overlies a thick bed of clay, in which are mingled many pebbles and small boulders. In its southern portion it is, for the most part, a high rolling prairie, the soil of which is a rich black loam, and covers with a depth of one to three feet the clay till of the moraine. This clay varies in thickness from 40 to 65 feet. Beneath it is a sand stratum from 20 to 70 feet thick, which furnishes a plentiful supply of water.

Gravel suitable for road purposes should be found in the higher ridges of this morainic region, but a careful search has not, as yet, revealed its presence in any locality. It is plentiful in the clay soil

of the uplands and seems to have been scattered through this soil and not accumulated in thick beds or deposits as in the moraines of central Indiana.

The largest deposit noted in the county was near West Creek, in section 7 (32 N., 9 W.). It was excellent in quality but was only about two and a half feet thick and was overlain with three feet of earth and underlain with coarse sand. A careful investigation may yet reveal deposits of gravel of workable size in the higher ridges east and west of Lowell.

About 80 square miles of the southern portion of the county are comprised in the Kankakee basin. This area is, for the most part, marsh land, which for several months of the year is covered with from two to five feet of water. When drained, as it some time will be, it will form one of the richest and most productive regions of northern Indiana.

All of the material used on the improved roads of the county has been shipped in from Illinois. As in Porter County, the cost of these roads was therefore higher than in the regions to the south and east, where road material is plentiful.

STARKE COUNTY.

Area in square miles	314
Population in 1900	10,431
Miles of public roads	650
Miles of improved roads	73
Percentage of roads improved	11.2
Miles improved with gravel	60
Miles improved with crushed stone	13
Average original cost of gravel roads per mile	$1,250
Average original cost of stone roads per mile	$2,200
Total original cost of improved roads	$103,600
Miles of improved roads (gravel) built in 1905	28
Miles of improved roads (gravel) contracted for 1906	83
First improved roads built	1901

Satisfaction of farmers with investment in improved roads—

"They kick before the election and before they are built, but after they once have them they would not do without them."

Authority........................Lee M. Ransbottom, County Auditor

Starke County lies in northwestern Indiana on the eastern side of the Kankakee River. Its topography is simple. Monotonous sand dunes interrupt more monotonous sand and muck flats.

There is no relief and hardly any diversity of soil. The sand is the yellow loose sort that drifts before the wind, and that grows little except sand burrs and scrub oaks. The gravel deposits in this county are very much like the occurrence of snakes in Ireland.

In California Township "gravel" pits have been worked on the Shilling and Rogers farms. In the former locality the material is poor, at least 60 per cent. being sand. It is hardly better than coarse, sharp sand anywhere in the pit. The latter locality, near Round Lake, is a little better as to quality.

On the Short farm, five miles southwest from Knox, there is a small deposit of fair gravel, enough probably to gravel 8 or 10 miles of road.

In North Bend Township, in the vicinity of Bass Lake, there is probably enough gravel to improve the important roads in the immediate neighborhood.

In Wayne Township, 3 miles northwest of North Judson, J. Kellar has a good pit in a ridge. Some 25 or 30 miles of road have been built from this pit, and there is probably enough gravel left for as much more. It is impossible here or anywhere else in Starke County to make any accurate estimate of the gravel in a bed. Sand seams are frequent, and the gravel often thins out within a space of 10 feet.

Throughout most of this county road material is being imported. For twenty miles of road to be built in the northern part of the county the gravel is to be shipped in from Walkerton. Some stone road has been built and more will be. In view of the scarcity of gravel here and its poor quality it is no doubt wise to ship in material that will be worth the expense of grading a roadbed. While stone roads will have a greater original cost, they will, if properly constructed, be more durable, and therefore cheaper in the end.

MARSHALL COUNTY.

Area in square miles	440
Population in 1900	25,119
Miles of public roads	800
Miles of improved roads*	150
Percentage of roads improved	56.2
Miles improved with gravel	450
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$315
Total original cost of improved roads	$141,750
Annual cost of repairs per mile on gravel roads 5 years old	$50
Miles of improved roads (gravel) built in 1905	50
Proportion of improved roads built since 1895	75%
Satisfaction of farmers with investment in improved roads	Good
Authority	H. L. Singrey, County Auditor

*All improved roads were built by working out the road tax. "The soil is sandy and water runs away almost immediately after falling, so the roads are in good shape most all the year. The Board of Commissioners has never felt it necessary to build, nor has there been any demand from the people for stone or gravel roads. Nevertheless, the roads in this county will compare favorably with those of any other county in the State." H. L. S.

This county lies in northern Indiana, the second from the north boundary and the fourth from the east. Plymouth is the county seat. The surface consists of the prominent Maxinkuckee lobe of the Saginaw moraine,—a succession of sand ridges and low marshes in the central portion. This morainal tract is flanked by the flat, sandy plain (mentioned more fully under Kosciusko County) on the east and the dreary sands of the Kankakee area on the west. This is pre-eminently a sand county. Very little clay occurs and very little gravel.

Vicinity of Plymouth.

South from Plymouth on the Michigan road one mile and again two miles two abandoned gravel pits show the arrangement of the drift in the morainal region. The gravel, a coarse, bouldery stuff, lies under yellow sand 15 to 40 feet deep on the ridge tops, 8 to 10 feet thick in the lower ground. The gravel is too coarse for good road material and the sand too fine. The Michigan road and other main roads in this vicinity are built of the sand, and in July the dust was 4 to 8 inches deep.

Southeast of Plymouth on the L. E. and W. Railway for five miles the country is a succession of low sand ridges and swamps.

The surface soil, where there is any, is sandy till. There is no gravel in sight, and none in the well sections short of 25 to 40 feet. As a rule the bases of the ridges are coarse gravel, but it is so deeply buried that it can not be worked except where water has cut away part of the sand. Even in such places the stripping soon becomes excessive. Yellow River, which cuts across this moraine, rarely gets down to gravel. The bars and the banks are accordingly sand or mud.

Culver and Vicinity.

The shores of Maxinkuckee Lake show the diversity of the morainal material. The lake is in a trough between two ridges having a general north-and-south trend. The ridge on the east is clay-topped, with sand and gravel base. Dillon's gravel pit in this ridge near the Vandalia Railway shows 15 feet of gravel under 2 to 6 feet of clay. Two wells in the top of the ridge show, respectively, 4 and 10 feet of clay overlying 20 feet + of gravel and sand. The gravel is not uniformly distributed, some wells missing it entirely.

The western ridge rises 35 feet above the water and is all sand of the yellow, "sugarlike" variety. There is no gravel here. The Vandalia Railway maintains a sand pit on the south shore of the lake. The product is at least 60 per cent. sand, and is totally unfit for road stuff.

In the extreme southern part of the county the sand and clay which forms the tops of the ridges have disappeared, leaving huge mounds of gravel or sharp, coarse sand. This substance makes good roads and is abundant. It reaches its maximum development along the Tippecanoe River in Fulton County.

Argos and Vicinity.

Argos lies near the eastern edge of the moraine. For a mile east of the village the morainal topography is distinguishable, although the ridges seldom have a relief of more than 10 feet. Generally the country is flat, and east of the moraine is a marshy sand plain which occupies the northeastern quarter of the county.

The soil on the moraine edge is a sandy loam. Down 6 to 15 feet (the latter for high ground) a fine water gravel occurs prac-

tically everywhere. All the wells in a radius of 1½ miles show it. It is not used for road-stuff because the abundance of water in it makes the work of extraction difficult. The low ridges have 2 to 6 feet of loam or clay on top, with gravel at the base. A pit has been opened in one of these ridges on Wisely's farm 2 miles northeast of Argos. The gravel, which is only fair in quality, lies under 2 feet of clay and is much mixed with sand. Practically every ridge in the vicinity is like this one; but it seems that the better water gravel should be removed by a gravel pump and then used in preference to the ridge material.

At Inwood, 6 miles east of Plymouth, the distribution of drift in the flat plain mentioned above is plainly evident. A gravel pit here shows the following section:

Section of Pit near Inwood.

		Feet.
1.	Soil	1
2.	Sandy yellow till	6—1
3.	Yellow, bouldery gravel	6—9
4.	Gray water gravel	2

In this vicinity there are thousands of yards of good gravel in sight with no expense for stripping. All the low ridges here contain sand or gravel. The low ground has a black surface soil with gravel beneath. The plain here, as in Kosciusko County, is gravel and sand. The expense of extracting the gravel is slight, and there is enough for all purposes.

The western strip of the county for about 2 miles in width may be dismissed in few words. It lies in the Kankakee sands and has no gravel.

KOSCIUSKO COUNTY.

Area in square miles	521
Population in 1900	29,109
Miles of public roads	1,300
Miles of improved roads	254
Percentage of roads improved	19.5
Miles improved with gravel*	250
Miles improved with crushed stone	4
Average original cost of gravel roads per mile	$700
Average original cost of stone roads per mile	$1,000
Total original cost of improved roads	$179,000
Annual cost of repairs per mile on gravel roads 5 years old	$50

Satisfaction of farmers with investment in improved roads—

They are well satisfied when a good road is made, but are very much dissatisfied with those already turned over to the county.

Authorities....G. W. McCarter, Ex-Co. Surveyor; Eff. Sharp, Co. Auditor

*All the improved roads have been built by the townships. Sixteen miles have been turned over to the county to be kept in repair. The cost as given is estimated, no accurate accounts having been kept. "We have no roads improved by contract and sale of bonds in this county, in the sense that they are so improved in the central and southern parts of the State. That is, we have never had a public road improved nor constructed through legal proceedings in the Commissioners' Court and Auditor's office. The present law has been of no help to this county, because it was not tried. Our natural gravel makes so fair a road most seasons of the year that our people seem satisfied with a small amount of graveling.

"True, we have had some graveling done, but it has been done in a haphazard way, with no system, so that one supervisor often destroys what a former supervisor or trustee has done. We have had a few miles of road graveled *in a way*, and accepted by the county commissioners, and afterwards kept in traveling condition by the county.

"The fact is, our people do not know what good roads are as understood by good road-makers. Our roads are, for the most part, common dirt roads, with now and then a cut or a fill, and without system, grade or anything else, only a place to drive along. It may be I am too hard on our roads, but I have seen so much better ones that my ideas regarding road construction are far different from those in practice here." G. W. M.

This county is in northeastern Indiana just east of Marshall County. It may readily be divided into three parts according to its topography. The eastern half is morainal, being principally in the area of the Saginaw lobe, and therefore sandy or gravelly. The southeastern portion, however, is on the Erie moraine and clayey. The western part of the county is flat and marshy; yet, strange to say, the divide between the Tippecanoe and the northward flowing streams lies in this plain. The third portion is a triangular strip of alluvium along the Elkhart River, entering from the north and comprising perhaps one-tenth the area of the county. The detailed description following will make clear the distribution of gravel in relation to these three areas.

Warsaw and Vicinity.

Warsaw, the county seat, is near the center of the county on the flat plain, and nearly surrounded by morainal ridges. There are a great many gravel and sand pits in this vicinity, the larger of which are listed and described.

The dredge ditch one-half mile south of Warsaw cuts through 4 to 6 feet of good gravel, chiefly overwash from the ridges round about. Two miles south of this ditch, at Pittenger's, the ridges are mainly gravel. The creek here has cut pretty deeply into the ridges, exposing gravel in the bluffs and stream banks. On the Pittenger farm there is a practically unlimited supply of fair gravel, tests showing its depth to be not less than 20 feet; and there are at least 80 acres of gravel exposed along the stream. About a mile northwest of this area is another almost as large and apparently as good.

West of Warsaw about two miles a pit has been opened on a hillside 400 yards north of the road. The gravel here is in thin layers 1 to 3 feet thick, separated by clay bands, the whole overlain by about 8 feet of clay.

Where the Warsaw and Winona trolley line crosses the Pennsylvania R. R. the cut is through a sand ridge with gravel base. The sand is 6 to 8 feet deep, with 10 feet + of gravel below.

The dredge ditch in the park passes through 4 to 6 feet of marl and muck, and reaches gravel at the bottom. According to the logs of the wells in the park this gravel substratum is 20 to 30 feet thick.

On the Pennsylvania R. R. 3 miles east of Warsaw there is a huge pit cutting off the end of a morainal ridge, from which the railroad has used some gravel. It is good material and practically inexhaustible, but the stripping is becoming excessive. This railway passes through a gravel district from Pierceton to Warsaw. Practically all the knobs are gravel, and often it is at the surface for yards at a stretch. The dredge ditch about 4 miles from Pierceton gets down to the great underlying gravel bed.

North of Warsaw the ridges flatten and are generally sand. Farther north the topography becomes flat and the soil sandy, with no gravel. The roads here are too sandy to become muddy; but dry sand is not a good roadbed.

About five miles south from Warsaw on the road to North Manchester an extensive pit has been opened in a ridge, from which a good quality of gravel is taken for road use.

Claypool lies in the clay portion of the county. Two or three pits have been worked in this vicinity, the largest at Mt. Pleasant, two miles north of Claypool. These pits are none of them large enough to be "workable," and the product is little better than quicksand. A dredge ditch one mile north cuts into some good gravel, but there is probably not much of it.

At Palestine, six miles southwest of Warsaw, the dredge ditches and hills both contain good gravel. In quantity it is practically unlimited, being found almost everywhere, and the quality varies from fair to excellent.

Northern Third of County.

From Leesburg north the surface is a flat plain, partly till, but chiefly gravel. Along the streams the gravel is at the surface. Elsewhere a clay or sand 2 to 6 feet thick covers the gravel. A dredge ditch one-half mile south of Milford and again a mile south has thrown up thousands of yards of excellent gravel. There is enough of it lying on the banks ready for use to serve the needs of this section for years. According to the well sections the gravel bed has only been scratched by the dredge, as they show from 50 to 60 feet of gravel.

At Gravelton, three miles east of Milford Junction, the B. and O. Railway maintains a big pit in a morainal ridge.

The northwestern corner of the county, comprising perhaps about one-eighth of its area, is marshy, with sand or clay knolls rising in it. They sometimes contain a little gravel, but it is poor material, totally unfit for road use.

Probably no other county in this part of the State has so much good gravel so well distributed as Kosciusko. True, there are portions of the county entirely without it; but at least two-thirds of its territory is amply provided for.

NOBLE COUNTY.

Area in square miles	417
Population in 1900	23,533
Miles of public roads	850
Miles of improved roads	600
Percentage of roads improved	70
Miles improved with gravel	600
Miles improved with crushed stone	None
Average original cost of gravel roads per mile*	$750
Total original cost of improved roads	$450,000
Satisfaction of farmers with investment in improved roads	Good
Proportion of improved roads built since 1895	40%
Authority	Jno. L. Henry, County Auditor

*All improved roads built by working out road tax at an estimated cost of $750 per mile.

Noble County is in northeastern Indiana, the second county from the northern and eastern boundaries. The village of Albion is the county seat. Practically the whole topography is morainal, consisting of steep-sided ridges and deep hollows between them. Many of these valleys contain lakelets, especially in the central part of the county. The lakes tributary to the Tippecanoe usually have swampy borders, while those tributary to the Elkhart River as a rule have the morainal ridges rising abruptly from the water.

The moraines comprise the Saginaw lobe in the northwestern, the Erie lobe in the southeastern and the interlobate moraine between the two in the central portion of the county. The last named occupies about two-thirds of the entire area. The distribution of gravel bears a direct relation to these moraines. The Erie lobe is mainly clay or blue till, with very small beds of gravel at depths ranging from ten to 60 feet. The Saginaw lobe, on the contrary, is mainly sand or gravel, with very little clay. The interlobate area presents a combination of the two, with the gravel always covered by till except where erosion has removed the latter. Thus, except in the northwestern part of the county, the gravel deposits that can be worked are confined to the larger streams and the sides of the ridges where the clay has been partly removed.

Vicinity of Albion.

A number of the ridge pits are worked in the vicinity of Albion. In the southwest edge of the village a gravel pit is sunk into the side of a morainal ridge. The upper 15 feet of the section shows

blue and yellow till, with probably 20 feet of gravel lying immediately below. This gravel varies much in composition, being for

try changes. Clay predominates, being often 60 feet deep. Most wells run 40 feet to first gravel and 60 feet to permanent water

NOBLE COUNTY.

Area in [illegible]

In the southwest edge of the village a g[illegible]
side of a morainal ridge. The upper 15 feet of the section shows

ue and yellow till, with probably 20 feet of gravel lying immeately below. This gravel varies much in composition, being for e most part sandy; and clay from the top mingles with the gravel it is taken from the bank.

Two hundred yards south from the pit above mentioned is anher much like it in appearance; but the gravel, of which some),000 yards have been removed, is better in quality. A well in e flat just below this ridge shows:

Section of Well near Albion.

	Feet.
Muck	4
Blue till	14
Gravel	4+

Other pits of the same nature occur at various places in this vinity. All show the gravel under 10 to 15 feet of till; and the ıpidity with which the clay thickens above limits the extent of the ork. Very few of these pits will yield 10,000 yards of gravel; ıt they are sufficiently numerous to serve the needs of the comunity.

The big cut along the B. & O. Railway two miles west of Albion ıows very well the general arrangement of the drift. This cut is ıuarely across the trend of a morainal ridge and is 400 yards long. or practically all of its length this section applies:

Section of Cut on B. & O. Railway Two Miles West of Albion.

	Feet.
Yellow till (clay chiefly)	10—12
Blue till	6 in.-2
Gravel, clayey or sandy	6

Some three miles west of Albion is the Elkhart River, with its ıt-floored valley. This valley has 2 to 6 feet of alluvium overlying ue till for the most part. The noses of the ridges that extend into .is valley have been eroded until practically nothing but the gravel left. It is clayey or sandy, but it is exposed with a clay top only ıur to six feet thick. Thousands of yards of poor material may › obtained in this valley at little expense for stripping.

Two miles south and west from Albion the character of the couny changes. Clay predominates, being often 60 feet deep. Most ells run 40 feet to first gravel and 60 feet to permanent water

gravel. There is no surface gravel in this section. All that is used comes from the Albion strip north or the Wilmot strip south. In this latter area the till thins again, leaving gravel often at the surface, and rarely under more than 8 feet of stripping.

Northwestern Portion of County.

There is a strip of country along the western side about five miles wide and running two-thirds the length of the county which is a flat plain—the valley of the Elkhart River and its tributaries. As a rule gravel occurs in this plain from 3 to 5 feet down. It is poor material, often nothing but quicksand. There is enough good material for the main roads, providing it be screened.

North and west from Albion to the Elkhart alluvium the county is morainal, but the ridges are much less pronounced than those south. The Saginaw moraine, with its sands and gravel, is the prominent feature here, as the Erie lobe, with its clays, is in the southern portion. In this northwest portion the soil is sandy, with only an occasional clay knoll. Every ridge is a sand ridge with gravel base; and sometimes, as 1½ and 2 miles north of Albion, the sand has been eroded, leaving the gravel covered with a foot or two of loam. This gravel is the same, to all appearances, as the water gravel that occurs farther south under 20 to 60 feet of clay.

Southern Portion of County.

The southern fifth of the county is marshy, with sand or clay hills rising island-like in it. The gravel deposits here are small, none running over 1,000 cubic yards in content. The material is uniformly poor. At Avilla, in the southeastern part, the drift is nearly all till, 20 to 60 feet deep. The topography is flat, with no gravel near the surface except some stream deposits and a little in the clay ridges. This condition prevails north from Avilla to Kendallville.

Northeastern Portion of the County.

In the vicinity of Kendallville the clay has been partly eroded, leaving sand and gravel somewhat closer to the surface. The drift here is mainly sand or a very fine-grained gravel. Wells reach heavy gravel at 20 to 35 feet in the low grounds and at 40 to 60 feet on the uplands. Three or four little pits in this vicinity show

4 to 6 feet of gravel under about 4 feet of soil and sand. The deposits are small and not very numerous. There is much low ground here, with a blue till underlying black muck. North from Kendallville the Erie lobe thins out and the ridges are mainly sand and gravel. This condition is best exposed about Rome City. Practically all the ridges, and the flat ground as well, are gravel or sand. The natural surface is better than most gravel roads. An abandoned pit of the G. R. and I. Railroad shows well the nature of all this county. Hundreds of thousands of yards have been removed here, with much good gravel still left in the bottom. The section shows:

Section of G. R. & I. Pit near Rome City.

		Feet.
1.	Sandy soil	1—2
2.	Sand and gravel	15—16
3.	Gravel	4+

The Lake Shore Railroad has a huge pit at the head of Sylvan Lake near Rome City. This pit covers 40 acres, with at least as much more in sight. The pit is in a ridge with a little clay at the top. All the higher ridges in this part of the county have gravel bases, often 60 feet thick, with clay above. The railway cut along the G. R. and I. exposes at least 20 feet of solid clay before gravel is reached. The lower ridges are all gravel and sand, appearing to be the remnants of former morainal elevations.

The road sentiment in this county is not very strong. There are no special levies for road purposes, most of the work being done by people "working out" their land taxes.

DEKALB COUNTY.

Area in square miles	369
Population in 1900	25,711
Miles of public roads	360
Miles of improved roads	125
Percentage of roads improved	34.7
Miles improved with gravel	125
Miles of crushed stone	None
Average original cost of gravel roads per mile	$750*
Total original cost of improved roads	$93,750
Authority	H. D. Boozer, County Auditor

*The improved roads were built by the township and the cost of $750 per mile is estimated.

This county, whose capital is Auburn, is in the northeastern part of the State on the Ohio line and in the second tier from the Michigan boundary. Its surface is partly moraine, partly till plain. The central half of the county is till plain, bordered by clay hills on the northwest and southeast. A narrow plain borders the St. Joseph River, and a small moraine occupies the extreme southeastern corner of the county.

In this county there is no outcrop of rock. Gas wells show a thickness of 300 to 400 feet for the drift. The moraine is interlobate between the Erie and Saginaw lobes, and is on the Erie side. This means that by far the greater portion of the morainal material is clay. In many parts of the county, and particularly on the till plains, both yellow and blue clays are found. Included in the heavy masses of clay there are little pockets of sand or gravel, in which water is found, at depths of 15 to 75 feet.

Auburn and Vicinity.

In the neighborhood of Auburn there are several gravel pits found near the streams where erosion has cut off enough clay to reduce the stripping. The gravel is not very good, being bouldery in some places and very sandy in others. The abundance of clay in the gravel assists in packing it on the road, and where proper grading is done a fair roadbed can be made. There seems to be a stratum of coarse sand and gravel along Cedar Creek, overlain by four to eight feet of clay. Back from the stream this sand can not be reached with less than 15 feet of overlying till. Even in the valley there are no surface indications of gravel, no sandbars in the stream and nothing but clay in the banks. Four miles west of Auburn there is a gravel, sand and clay pit from which stuff is taken for road repair. It is poor material and makes bad roads.

Vicinity of Butler.

At Butler and in the northeastern part of the county generally the surface is a heavy, tough clay on the knolls and black, mucky soil in the valleys. There is no indication of gravel and no workable pit in this vicinity. About 4 miles east of Butler there are a number of little holes from which sand and sandy gravel have been extracted. All of them together will hardly make one workable

pit, and the material is very poor. On the streets of Butler it grinds to mud in a year. Wells here run 40 to 60 feet to water, through clay, sand and hardpan, with gravel for the water-bearing stratum.

St. Joe and Vicinity.

St. Joe is 10 miles southeast of Auburn on the St. Joseph River. This stream has cut down through the heavy clay, and reveals small lenticular pockets of gravel and sand, which are sometimes close enough together to make workable pits. One such is just south of the B. and O. station. Probably 15,000 yards have come from here. Another similar pit, but not so good, lies a few hundred yards east. The river has a number of sand and gravel bars formed from the washings of the slopes. The gravel is none of it excellent, being mostly a coarse sand. The till of this county, however, when well graded makes a very fair road of itself, and with a top dressing of quicksand gives a good roadbed.

A small gravel pit is found at Newville and a large one, containing probably 15,000 yards, at Spencerville. From the latter the Spencerville-St. Joe pike, a good road, has been built.

Waterloo and Vicinity.

Near Waterloo the overlying till thins out. This fact, in connection with the eroding action of Cedar Creek, reveals the gravel and sand at a number of places. Just east of Waterloo the township owns a pit in a bank, from which four or five thousand yards of gravel have come. The stripping is red clay, which in small quantities is a valuable constituent of gravel on account of its packing quality. This till seems to be of quite irregular thickness, and on account of its compactness has not eroded very rapidly. As a result the valley of Cedar Creek has many elevated banks and knolls, all of which contain gravel under the clay. While this clay has undoubtedly helped retain the gravel in place, it is now the chief item of expense in the working of the gravel on account of the cost of stripping. The pit at the cement-block works east of Waterloo shows:

Section of Pit East of Waterloo.

	Feet.
1. Red till	4—6
2. Sand	2
3. Gravel	6

The gravel contains much sand, probably 60 per cent. of the whole. Across the stream, 200 yards east of the above pit, the bank of the creek shows 4 feet of clay and 4 feet + of gravel.

Near the pumping station the abandoned pit of the Lake Shore Railway, from which perhaps 2,000,000 yards of gravel have come, shows the nature of the country. The average section here shows 2 to 4 feet of clay, with 6 to 12 feet of gravel below.

Another pit similar to the sections given above occurs at a place 1.5 miles northwest of Waterloo.

As a whole the entire till plain within a radius of two miles of Waterloo is underlain with gravel from three to eight feet thick, under two to four feet of clay. Below the gravel, hardpan occurs 2 to 10 feet thick, with a coarse, bouldery gravel beneath. In this area there are probably between two and a half and three million yards of gravel available. The expense of stripping will be considerable in places, and the gravel is not of the best quality. It makes a fairly satisfactory road, however, and should be developed.

This Waterloo gravel belt follows Cedar Creek three miles or more to the northwest, but the stripping soon becomes excessive. As one goes north the overlying clay becomes thicker, until at Summit, five miles north, it is more than 30 feet thick. There is no gravel here, and no indications of gravel until one approaches Steubenville, in Steuben County, where the drift thins out again.

In the southwestern part of the county, near LaOtto, there is no gravel, the red till on the surface being underlain at a depth of six feet by hardpan and blue till.

This county is pre-eminently a clay county, the average thickness of the drift-till being about 50 feet. There are local thinnings of the surface clay to 15 feet, but these are rare. Beneath the till there is a sheet of sand and gravel which in most places is so deep as to be inaccessible. Where the streams have cut deeply into the surface the gravel beds are sometimes so nearly exposed as to be workable. On the whole, the gravel prospect in this county is poor.

WHITLEY COUNTY.

Area in square miles	336
Population in 1900	17,328
Miles of public roads	651
Miles of improved roads	542
Percentage of roads improved	83.2
Miles improved with gravel*	542
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,150
Total original cost of improved roads	$623,330
Annual cost of repairs per mile on gravel roads 5 years old	$50
Miles of improved roads (gravel) built in 1905	13
First improved roads built	1886
Satisfaction of farmers with investment in improved roads	Good
Authority	Chas. E. Lancaster, County Auditor

*But eleven miles have been built by contract and sale of bonds. The remaining 531 miles are township roads, the average cost of which was computed from figures given by the trustees of the county.

Whitley County is in the northeastern part of Indiana just west of Allen County, and has Columbia City for its county seat. Its topography is diversified. The southwestern corner of the county is, as a rule, flat, black land, with a few ridges coming into it from the moraine. The remainder of the county is morainal. The strong Erie-Saginaw lobe enters the northwest portion and fuses with the Mississinewa moraine. Eel River follows the latter across the county. The extreme northern part of the county is swampy or marshy. A few clay ridges extend into it from the Erie moraine. In all this morainal district the clay hills furnish the characteristic feature. In the central part of the county they rise 40 to 60 feet above the narrow valleys; toward the west they become often 100 to 120 feet high and very steep.

This county is pre-eminently a clay county. The surface soil is a stiff yellow clay from 30 to 100 feet thick. Underneath the clay gravel and sand occur to a depth of more than a hundred feet. Gravel evidently will be exceedingly scarce except where Eel River and the larger creeks cut down through the clay. Occasionally a dredge ditch gets down deep enough to touch the top of the gravel. In Cleveland and Richland townships pumps have removed some of this water gravel. It is excellent material, but not very abundant.

Eastern Portion of the County.

The largest single deposit of gravel in the county is on the Aker farm, 4½ miles east of Columbia City. The tests made show that at least 160 acres are underlain with gravel or sand at a depth of 1 to 3 feet. In the pit in this deposit an average thickness of 10 feet is indicated, and various other holes show about the same thickness. Judging from the exposures, about 60 per cent. of the total deposit is gravel. This seems to be a river deposit. It lies inside a bend of the river and is 30 to 35 feet higher than the great bed of gravel underlying the till. There is no doubt that a gravel supply could be developed here sufficient for the use of all the region within hauling distance.

Vicinity of Columbia City.

Practically all the workable deposits in Whitley County are along Eel River; and they seem to be terraces of river origin. Many of the smaller beds are simply the exposure of the underlying gravel by the erosion of the clay. These, however, are usually small. For example, one mile north of Columbia City there are two small pits in little knolls. The total product of the two is probably less than 3,000 yards, and its quality is poor. These pits are in the river bluffs, and soon become worthless because of excessive stripping. In this vicinity there are at least five pits, all of which must be soon abandoned, and their total product will hardly be 10,000 yards.

South of Columbia City about two miles there are several small pits much like those described above. They occur along a small stream that has removed some of the clay. There is still left, however, about 8 feet of stripping.

Western Portion of County.

In the vicinity of Larwill the deposits are all small. Two pits have been opened in this region, one on the Hayden farm, another on the Helfrich place. The two together will not run 10,000 yards. In this part of the county some gravel is taken from ditches with pumps, but it is scarce.

At South Whitley the gravel is practically inexhaustible. The town itself is built upon a little plain that is probably a large ter-

race. Gravel occurs here under 2 to 4 feet of loam, and extends down 10 to 16 feet. About 400 yards southeast of the town there is a typical terrace deposit. The pit here is large enough to allow 40 wagons to load at once. The gravel occurs 12 to 16 feet deep under 4 feet of soil at the most. Thousands of yards have been removed, and there is much more left, the bed covering about 80 acres.

Two hundred yards up the river from the above pit is another like it, and practically the whole course of Eel River through this county shows the terraces mostly gravel. There are many beautiful examples of cross-bedding and sorting of material by water.

Away from Eel River the outlook for gravel in Whitley is gloomy. Small local deposits occur, sufficient to maintain the principal roads, but the material is not good, and there is an insatiable demand for more gravel for repair work. The Eel River terraces furnish enough gravel for the whole county; but it is poorly distributed. Besides the Aker farm, already described, other terrace deposits occur in this county. Six miles from Columbia City and two miles from the Aker place there is another deposit much like it and half as large.

FULTON COUNTY.

Area in square miles	382
Population in 1900	17,453
Miles of public roads	682
Miles of improved roads	52
Percentage of roads improved	7.6
Miles improved with gravel	52
Miles improved with crushed stone	None
Average original cost of gravel roads*	$1,231
Total original cost of improved roads	$64,040
Annual cost of repairs per mile on gravel roads 5 years old	$38.46
First improved roads built	1890
Proportion of improved roads built since 1895	60%
Satisfaction of farmers with investment in improved roads	Good
Authority	K. W. Shore, County Auditor

*Of the 52 miles of gravel road, 44.54 miles were constructed by the townships and turned over to the county. Their estimated cost is $1,000 per mile. The remaining 7.46 miles were purchased from a toll road company in 1895 for $19,500.

In a general way this county is divided into two large triangles by the morainal hills of the Saginaw ice-tongue, the moraine front

coming into the county at the southeast corner and leaving the county two miles east of the northwest corner. The northern triangle is, for the most part, underlain with gravel, while the southwest one is almost entirely without it, a great part of its area being occupied by a swamp.

Rochester and Vicinity.

Three miles north of Rochester and three-fourths of a mile across the Tippecanoe River one finds the first of the morainal hills, and they are here typical of the whole. They are of gravel and clay, rising often 60 feet above the narrow, deep gorges between. Almost without exception they contain at least 60 per cent. of gravel, the clay being partly on the top and partly on the bottom. The gravel supply is practically inexhaustible and is for the most part easily accessible. Every hill is a gravel bed, and the material is excellent. It occurs in beds of 8 to 20 feet in thickness under 4 to 6 feet of clay. From these hills gravel has been carried out in the "aprons" to distances of 3 to 6 miles. Thus in the creek bed one-half mile north of Rochester 6 to 8 feet of fine gravel are exposed under 2 to 4 feet of soil. Within three miles of the moraine front to the south this same condition holds. Every well, ditch and stream reveals gravel, which extends down to a depth of at least 6 feet.

North of the morainal hills many smaller ridges occur in a rolling plain. The ridges are uniformly gravel, and the same material underlies the plain. Thus for 4 miles east of Rochester the surface is a flat, broken only by inconspicuous ridges. The lowlands are covered by 2 to 4 feet of soil, beneath which occurs 4 to 6 feet of gravel. In the region about Akron, in the southeast part of the county, the same condition is met with. In fact, gravel occurs in the northern triangle almost everywhere. Where it is not exposed by ditch or creek, test holes find it in 95 per cent. of the attempts at a depth of 2 to 5 feet.

Two miles north of Rochester the L. E. and W. Railroad has purchased a tract of ground containing three of the morainal hills which are typical of all those in the county. These ridges contain 16 to 25 feet of gravel slightly mixed with sand. The tops are clay or sand, but the bases are clean gravel. A hill south one

mile contains little gravel, but much coarse sand. All the ridges extend northwest and southeast, and there are usually 4 to 8 of them in the series.

Manitou Lake, a beautiful body of water, lies one mile southeast of Rochester in one of the narrow, deep valleys between morainal hills. Its banks are from 6 to 40 feet high, and are either sand or gravel at the surface, with gravel always at 5 to 10 feet below the soil on top.

One-half mile southwest of Rochester three gravel pits in close proximity show 5 to 8 feet of gravel under 2 feet of soil. They are in a low ridge which extends down into the flat country, the great marsh of Fulton County. This lowland occupies about half of the southern triangle. It is a sand flat broken at long intervals by low ridges of wind-blown sand. There is no gravel here, even at depths of 50 feet in the wells. This area is much like the sandy regions of Newton and Pulaski counties, to be mentioned on subsequent pages. The dune character of the ridges is plainly shown by contrast with the water-laid morainal hills. The latter are rather regularly placed and contain rounded pebbles; sections in pits show plainly the sorting power of water. The sand hills, on the other hand, are found in no regular direction, with angular pebbles and without stratification marks.

Vicinity of De Long.

Aubbeenaubbee Township forms the northern apex of the southern triangle. At De Long, on the Erie Railroad, the soil is clay with a gravel subsoil. The clay is 2 to 4 feet deep and is underlain almost everywhere with 2 to 5 feet of gravel, usually of poor quality. The low ridges are uniformly sand with gravel bases. The whole region about the station is frontal moraine, the hills lying 2 to 3 miles to the north. As one goes south the sand becomes predominant. Three miles south of De Long the clay has entirely disappeared and the yellow, shifting sand of the marsh area covers everything.

Kewanna and Vicinity.

Kewanna is in the southwestern part of the county, west of the marsh. Even here the sand covers the surface, and as usual is without gravel. At three points, viz., one and one-half miles

south, two and one-half miles south and one and one-half miles northeast, pits have been sunk in low ridges and a coarse quicksand removed and used for road-stuff. It is worthless for this purpose, however, and ought not to be used. The sand here is not so thick as in the marshy area; and where the ditches are more than 5 feet deep they uncover numerous small gravel pockets running from 500 to 3,000 yards. This gravel is coarse, but better than the ridge stuff. It is only in this southwest township that any gravel is to be found in the southern triangle farther from the moraine hills than 4 miles. Taken as a whole, the road material here is scarce, and the quicksands used instead do not improve matters.

PULASKI COUNTY.

Area in square miles	437
Population in 1900	14,033
Miles of public roads	875
Miles of improved roads	80
Percentage of roads improved	9.1
Miles improved with gravel	67
Miles improved with crushed stone	13
Average original cost of gravel roads per mile	$1,383
Average original cost of stone roads per mile	$2,600
Total original cost of improved roads	$126,500
Miles of improved roads (gravel) built in 1905	40
Miles of improved roads (stone) built in 1905	13
First improved roads built	1902
Satisfaction of farmers with investment in improved roads	Good
Authority	Ellis S. Rees, County Auditor

At Francesville, in the southwestern part of the county, there is no gravel exposed either by the big ditches or by wells. Occasional small pockets occur, but they are not "workable." The whole township, however, is underlain, at depths varying from 6 to 14 feet, by limestone which can be obtained in sufficient quantity to macadamize all the township roads. At Medaryville, six miles north, the sand covers everything and conceals the gravel if any occurs. No wells or ditches show anything but sand or muck. All the northwestern part of the county is in the same condition. Every favorable spot and many others was tested and nothing found except an occasional thin streak of coarse sand. This sandy area extends across the county, bending somewhat to the north on the eastern side.

Winamac and Vicinity.

In the northwestern corner of the town is a gravel bed in a ridge showing at least 16 feet of gravel under 3 to 4 feet of clay and sand. The quality is fine, but on account of the deposit running back under the hill no estimate of the quantity can be made. The excessive stripping renders the gravel expensive; probably not more than a fifth of the total amount is available, and this will be about 80,000 yards. There is about 2 to 8 per cent. of clay in the gravel, furnishing a good cementing material.

In the south side of the town a small bed of gravel containing not more than 6,000 yards exists under 2 feet of soil. Under this comes 4 feet of coarse boulders and then 4 feet of sharp, fine sand.

Three miles south of Winamac, where the road crosses the river near the railroad bridge, there is a gravel deposit of perhaps 10,000 yards. The gravel composes perhaps 60 per cent. of the total, the rest being clay and coarse boulders. The material is not of much value and is not worth using where anything else can be had.

Three and one-half miles west of Winamac, south of the road 100 yards, a bed of gravel occurs about 150 yards in radius and 3 to 5 feet thick at the center. The stripping is 2 feet or more. The gravel is fair, but contains much clay and is somewhat coarse. Test holes show that the bed does not extend more than 100 yards from the center; and in most of the productive area the thickness is not over 12 inches. Altogether there can not be much more than 6,000 or 7,000 yards of gravel here.

The Tippecanoe River for 4 miles up the stream and 6 miles down from Winamac offers no gravel. The islands are for the most part sand, and show the character of the stream load. The banks are commonly low and composed of sand or clay.

In the dredge ditch 6 miles west of Winamac and 1 mile south, the dredge cut at a depth of 7 to 9 feet into the top of a gravel bed extending for a mile up and down the ditch and varying from 3 to 12 feet in thickness. The gravel is excellent in quality, but the thickness of the soil makes it impossible to get at except by steam dredge or gravel pump. This gravel carries the water of this part of the county and seems to occur everywhere in a radius of 4 miles at a depth of 7 to 25 feet. The locality in which the

above bed occurs is near the Ambler farm. Two and one-half miles northwest of this bed another much like it is revealed in the "Monon" ditch. All the wells find their water supply in this gravel stratum at various depths. The thickness of the gravel varies from 5 to 20 feet.

Somewhat farther north than the above localities and four miles west of Denham gravel is again exposed in the dredge ditch, averaging 3 feet in thickness under 6 to 8 feet of clay and sand. This gravel is very sandy and its use is not to be commended.

Vicinity of Lakeside.

At Lakeside, in the south central part of the county, there is a fine gravel pit in the top of a clay ridge. The material averages at least 10 feet in thickness and in many places is 25 feet. It covers approximately four acres, and may fairly be estimated to contain 150,000 yards of excellent blue-gray gravel. This is by long odds the best bed in the county and is at least equal to any other seen during the summer. It is easily accessible and will gravel all the roads within hauling distance.

In the central part of the county 117 sand hills were carefully examined, gravel being found in 6, but not in paying quantities. Experience shows that there is no use in looking for gravel in sand ridges. Some little deposits will be found, but they are so small as not to be worth the trouble of finding. The clay hills are more favorable.

Star City and Vicinity.

One and a fourth miles west of Star City a gravel bed exists in a clay hill under 4 feet of clay and soil. The gravel is pretty coarse and sandy in spots. By careful selection, and especially by screening, a satisfactory road material might be obtained. The ditches, however, will solve the gravel problem in this vicinity. Wherever the ditches run over 5 feet in depth the dredge has uncovered fine gravel, and enough has been thrown out in excavating to build half the roads in the region. If the ditch were deepened 2 feet it would supply ample material for all the highways. For three miles west, northwest and southwest of the town gravel is always revealed by the ditch, and its thickness varies

from 4 to 9 feet. Away from the streams the same stratum is met under 6 to 14 feet of clay. There is no need, however, of working these deeper deposits until all the gravel exposed by the ditch is exhausted.

The Indian Creek ditch in this corner of the county reveals gravel in almost its entire course, and often cuts through the beds, showing "hardpan" underneath. The gravel is uniformly good, 4 to 8 feet thick and is often uncovered by the excavation.

It is apparent from a study of the foregoing sections that the southeastern fourth of the county is underlain with gravel. In the southwest corner, extending east for about 5 miles, the underlying rock is covered with 18 inches to 40 feet of loam and sand. The northern part of the county for 8 miles from the northern line is sand hill and marsh, with no gravel in hauling distance. Everywhere else in the county good gravel is found under 6 to 25 feet of clay and sand; but except along the ditches it is expensive material to obtain. Considering, however, the number of ditches and their courses, the southeast corner of the county may build roads rather more cheaply than most other areas. This gravel seems to be intimately connected with the moraines of Fulton County, the sand and clay now on the surface being partly the overwash of those moraines and partly due to subsequent advances of the ice.

Stone in Pulaski County.

The southwestern township of this county is underlain by limestone precisely like that so extensively quarried at Monon. In most of the area the rock is found at depths greater than 7 feet. On Monon Creek, however, about three miles southeast of Francesville, and at a point 1½ miles northwest of the same town the rock comes nearly or quite to the surface. At the latter place some little crushing has been done. There is no reason why this exposure should not be worked extensively. At comparatively little expense for quarrying and with no excessive hauling the entire country round about might have good macadamized roads. There is no gravel near, and the rock is as good as any employed in neighboring counties.

JASPER COUNTY.

Area in square miles	565
Population in 1900	14,292
Miles of public roads	600
Miles of improved roads	47
Percentage of roads improved	7.8
Miles improved with gravel	47
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$2,500
Total original cost of improved roads	$117,500
Annual cost of repairs per mile on gravel roads 5 years old	$125
Miles of improved roads (gravel) built in 1905	5
Miles of improved roads (gravel) contracted for 1906	8.5
Miles of improved roads (stone) contracted for 1906	6.5
First improved roads built	1890
Miles of improved roads built since 1895	41
Satisfaction of farmers with investment in improved roads	Good
Authority	Jas. N. Leatherman, County Auditor

An east and west line across this county from Fair Oaks, on the Monon R. R., to Pleasant Grove, on the Gifford line, divides pretty accurately the sandy Kankakee drift from the gravel bearing drift of the southern part of the county. North of this line we find the sand hill and flat bog topography of the region to the north and west; and here, as there, no gravel occurs. The poverty-stricken yellow sand hills are prominent, with long stretches of wet marsh between, and occasionally a little clay is mingled with the sand. South of the line a great many ridges occur, some of clay, some of sand. Without exception the clay ridges contain no gravel. In the bottoms of the sand hills, however, pockets of gravel occur in a hit-or-miss fashion. It is rare that one of these pockets contains 4,000 yards; but in certain regions they are numerous enough to build the roads in the vicinity. Farther away from Rensselaer than four miles, however, the clay predominates, with no gravel. The sentiment in this county seems to be for crushed rock, and because of the worthlessness of most of the gravel little else is to be expected.

Vicinity of Rensselaer.

About 1½ miles south of Rensselaer is a ridge, extending east and west for about three miles, which shows very well the pockety nature of the gravel deposits in this county. At a point 1½

miles south of the city, across the road from the "College" Cemetery, is a sand pit in the western end of this ridge. Here, under 2 to 4 feet of sand, there lies a bed of very excellent gravel. It is bowl-shaped, 10 feet thick at the center, thinning out in all directions to less than a foot, in a radius of 40 feet. As the bed extends into the ridge in three directions the stripping increases so that not more than half the deposit is available. One and one-fourth miles east of the above deposit another bed is revealed in the same ridge. Here, however, the gravel is badly mixed with sand. The section shows:

No. 2.	*Feet.*
1. Soil	1
2. Sand	2
3. Gravel	6—8

No. 3. One-half mile southeast of No. 2 is the Adams pit, showing much the same section. The gravel here is fairly clean and is 4 to 8 feet thick under 2 feet of soil.

No. 4. On the next farm to the Adams pit and half a mile from it is a smaller bed showing 6 feet of gravel under three feet of sand. The gravel here is clean and fine grained.

No. 5. Half a mile east of No. 4 is still another bed in the ridge showing about the same section. A fair estimate shows in No. 1 3,000 yards of gravel, in No. 2 5,000 yards, in No. 3 12,000 yards, in No. 4 5,000 yards and in No. 5 5,000 yards, or a total of 30,000 yards. There is vastly more gravel than this in the ridge, but the heavy stripping renders most of it expensive. An attempt was made to connect the various exposures above, and of 37 holes put down 23 showed from 6 to 8 feet of gravel under 2 to 5 feet of sand. I am confident that there are at least 100,000 yards of gravel in this ridge easily accessible. Yet where the above five pits are located, allowing the graveling of four miles of road with less hauling than a mile and often half a mile, the highway was almost impassable after an August shower!

South of this ridge there is no gravel in Jasper County. Two and one-half miles south of Rensselaer is the Big Slough, a great ditch which drains a flat marsh bounded on the north by the gravel ridge and on the south at a distance of two miles by sand hills. For six miles beyond this slough the sand lies deeply upon

the surface. There is no gravel here nor anything else of any value. South of the sand hill country for four miles to the county line the surface is a sandy prairie, the shallow soil resting upon a sandy shale. Three days were spent in putting down holes into the soil and in quizzing well diggers. Both were without results, except that no gravel was found. The shale is far too friable and soft for road material. All roads in this vicinity are impro̊ved, if at all, with rock imported and hauled from Remington.

Northeast of Rensselaer four miles, on the John Groom farm, is a flood deposit of the river, known as the Beaver Dam. It is a fill in the valley and is composed largely of a very coarse sand and fine gravel, with some intermixture of soil and mud. The deposit is almost half a mile long, from 20 to 60 feet wide and averages 4 feet in thickness. On the roads it packs well and forms a very good material. Half a mile north from the bridge at the lower end of the Beaver Dam there is a gravel pit in the side of a sand ridge extending about three miles north and south. The gravel is pretty well mixed with sand, but its worst drawback is the lack of continuity of the bed. In this pit it varies from 2 to 12 feet in thickness. Almost anywhere in this ridge gravel may be found, but always in pockets, usually with less than 1,000 yards in capacity. But the number of these pockets and the little stripping necessary make the ridge a valuable source of road material. Farther east than this the ridges are all sandy and have no gravel.

Four miles straight north of Rensselaer there is a gravel bed in the ridge whose contents are about 15,000 yards. The material is very sandy, and is valuable only because no better is to be had near. The gravel is about 6 feet thick under 2 to 4 feet of soil.

Northwest of Rensselaer the sand ridges with intervening flats occur, and here there is no gravel.

Vicinity of McCoysburg.

At McCoysburg, six miles east of the county seat, the topography is a repetition of the sand hills and flat bogs of northern Lake and Porter counties. The ridges are sand from 8 to 12 feet thick, and on the flats the sand is 2 to 4 feet deep. One mile southeast of the station a pit has been opened in a ridge and some

of the material used on the road. It is absolutely worthless. Three miles west of here a small pocket of gravel, not to exceed 5,000 yards, occurs, but it, too, is worthless because of the large proportion of sand.

In the eastern edge of Jasper County, about five miles west of Francesville, on the Tillot ranch, is a pocket of fair gravel containing some 20,000 yards. There is considerable stripping, but almost all the material is accessible.

About three miles northwest of the above deposit there is another bed of poor gravel on the Gifford ranch. This deposit contains probably 60,000 yards and is accessible by rail. Unless it be screened its quality will prevent its use where shipment is necessary.

Stone in Jasper County.

In the edge of Rensselaer, south and a trifle east from the courthouse, is a primitive crushing plant which makes use of the stone found in the bed of the Iroquois River. The upper three feet of rock here is a sandy limestone too soft and friable for road use. Under this is 2 feet of black to brown limestone, hard when fresh, but crumbling upon exposure. Below this layer is a stratum 14 inches thick of good blue limestone. The rock is not worked deeper than this stratum on account of the water seeping into the pit. Most of the rock taken out is not of great value in road building, and the influx of water prevents the use of the better grades farther down. A section here shows:

Section of Quarry at Rensselaer.

	Feet.	Inches.
1. Soil	2—2	...
2. Sandy limestone	3	...
3. Brown or black limestone	2	...
4. Blue limestone, hard	..	14+

Four miles east of Rensselaer, at the station of Pleasant Ridge, a brown limestone crops out, similar in quality and texture to the top stratum at Monon. The entire ridge is underlain by this rock at depths varying from 18 inches to 3 feet. The ridge is about 400 yards long and 200 yards wide, the stone showing in wells to a depth of 20 to 30 feet. Occurring as it does at least three miles from any gravel, it might be of much importance.

The knolls and ridges to the east of this point are also underlain by this rock at about the same depths.

One-half mile north of the station at McCoysburg a ridge is formed of limestone like that at Pleasant Ridge. The stone is hard, somewhat siliceous and should make a fair road material, especially valuable because good gravel is not to be obtained anywhere within a reasonable hauling distance.

In the vicinity of Remington, in the southern part of the county, a sandy shale has in the past been used for road-stuff. It is absolutely worthless and is no longer employed.

NEWTON COUNTY.

Area in square miles	380
Population in 1900	10,448
Miles of public roads	632
Miles of improved roads	117
Percentage of roads improved	18.5
Miles improved with gravel	11
Miles improved with crushed stone	106
Average original cost of gravel roads per mile	$1,100
Average original cost of stone roads per mile	$1,800
Total cost of improved roads	$192,096
Annual cost of repairs per mile on gravel roads 5 years old	$25
Annual cost of repairs per mile on stone roads 5 years old	$25
Miles of improved road (stone) built in 1905	10
First improved roads built	1895
Satisfaction of farmers with investment in improved roads	Good
Authorities	A. E. Purkey, County Auditor; Dr. R. C. McCain

This county is almost without gravel. The northern two-thirds, as far south as the Iroquois River, is the old Beaver swamp, a part of the Kankakee lowlands, with Beaver Lake, now drained, near its center. Extending irregularly through the swamp there are many sand ridges 10 to 30 feet high, composed of fine yellow sand, sharp pointed and containing few pebbles. These fragments are all angular, indicating little water action. The whole area is so strikingly like the sand dunes of Lake and Porter counties that one is convinced that we have here to do with the beaches and sand spits of an old lake, of which Beaver is an insignificant remainder. At present these sand hills are moved somewhat by the wind. Every heavy windstorm sweeps a fine cloud of sand before it, and the south and west sides of the ridges

often have hollows scooped out. The angularity of the pebbles might be taken to indicate that little wave action has occurred; but they form a relatively very small per cent. (less than ½ of 1 per cent.), and are so thoroughly covered with sand that the latter must have offered some protection. Even in the flat marshes the sand is from 10 to 30 feet thick, effectually preventing any search for gravel; and the well sections in this locality all show an absence of it. In all the northern part of the county, except the two places mentioned below, no trace of gravel was found, although 5 days were spent in probing the most likely places, some 300 holes having been dug from 8 to 15 feet deep. In only two places were any signs of gravel to be found. One of these is two miles north of the town of Brook, in Sec. 5. The deposit here is some five feet thick; but it is nothing more than a coarse quicksand, and is totally unfit for road use. A mile of road built of similar material two years ago is now worthless; and the large percentage of sand leaves the road at least no better than it was before. A bed of gravel very similar to the above occurs 2½ miles south of the village of Morocco. Here the material is somewhat more pebbly than in the above bed, but even here the proportion of sand is about 80 parts in one hundred. From this deposit three miles of road were built some years ago; but the material was worthless and no more is being used.

Southern Portion of the County.

The two southern townships, Grant and Jefferson, are somewhat different in character from the northern part of the county. The surface here is black soil, with occasional sandy ridges. Under the black loam, at depths of 3 to 40 feet, sand is encountered; but there is no gravel here except a small deposit in the extreme southeastern corner of the county. Here, near the Moran Bros.' icehouse, ¼ mile from Goodland, a bed of gravel containing probably 5,000 yards exists under 5 feet of sandy soil. The gravel is poor, but is better than any other in the county. In Jefferson Township I put down 60 holes and in Grant 30, in places where the loam was not too thick; but no gravel was encountered. Not a well in these townships shows gravel, and none is revealed along the streams. Occasionally along the Kent ditch north from Kent-

land a few pebbles are mingled with the sandy clay, but there is no nearer approach to gravel. Practically every quarter section in these townships has been examined, but no gravel has yet been found.

As far as gravel roads are concerned, Newton County must always be without them if it relies upon its own resources. The southern part of the county may have excellent macadamized roads, however, the rock coming from the large quarry between Kentland and Goodland. The rest of the county not too far removed from the railway may macadamize its roads with imported stone from Momence, Ill., Monon, Ind., or Logansport. The first named rock seems rather soft for road material, but excellent results have followed from the use of the latter two, especially the Monon rock.

Road Making Stone in Newton County.

Three miles east of Kentland, near the Pennsylvania Railway, several quarries of limestone are found in a tract of land embracing about 200 acres. Two large quarries, the McKee and the Means, are now abandoned; the United States Fidelity and Guarantee Co.,* of Baltimore, are now (1904) operating a large plant 200 yards northeast of the McKee quarry.

The rock in all these quarries is very much folded and faulted. In the U. S. F. & G. quarry the average dip is 80° to 85° N. 70 W. In some parts of the pit the rock is perpendicular, and the direction of dip varies widely. In the McKee quarry the dip is uniformly 80° to 85° S., 40 E. Half a mile west is the Means quarry, where the dip varies from 20° to 60° N., 45 W. All these quarries are on the sides of a low ridge extending in a semicircle a little over half a mile east and west, and 600 yards north and south. Along the top of the ridge south of the Means quarry the rock occurs 4 feet down. At the McKee quarry it is found at 6 to 8 feet, and north of the U. S. F. & G. quarry 300 yards 6 to 8 feet. On the south side of the ridge the rock occurs 200 yards south of the summit 4 to 8 feet down. Beyond these limits the stone plunges rapidly down. At distances varying from 100 yards to 400 it is found, if at all, at depths of 25 to 60 feet.

*This quarry is now operated under the name of the W. F. Goff Stone Company.

Plate III.

(a) Tilted Niagara Limestone at McKee Quarry, near Kentland, Newton County.

(b) Quarry east of Delphi, showing tilted Niagara strata. (See p. 272.)

This ridge, of Niagara limestone, offers a rather complex problem; but it seems that it is a synclinal fold, much broken in the folding. This view is borne out: (1) By the dip of all exposed strata on the north side of the ridge being north or northwest, and the dip of all those on the south side being to the south or southeast; (2) By the abruptness of the edge of the field beyond the limits of the ridge, and (3) By the uniform thickness of the drift (20 to 40 feet) on all sides of the elevation.

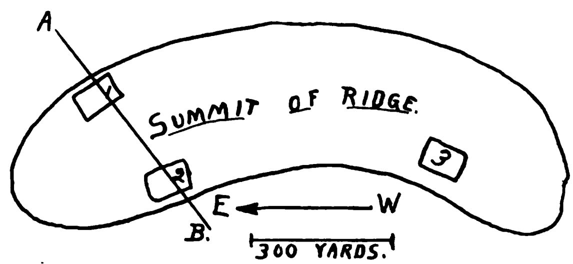

DIAGRAM OF ROCK-BEARING RIDGE
IN NEWTON COUNTY.
1= McKEE QUARRY 2= U.S. F & G QUARRY
3= MEANS QUARRY

Fig. 24.

For the most part the rock in this area is a semi-lithographic limestone, running often to chert, very hard and blue to brown in color. It breaks, when fresh, with a conchoidal fracture. In the U. S. F. & G. quarry there are exposed 60 feet of rock in 30 strata, varying from 3 feet to 2 inches in thickness. Across the ends of the almost perpendicular strata five feet of rotten stone lie, the rock below being hard and of very uniform texture. The section here shows:

Section of U. S. F. & G. Quarry.

		Feet
1.	Soil	6"—2
2.	Weathered rock (limestone)	4 to 5
3.	Hard, blue or brown limestone	45 to 55

All the rock is crushed together. The softer weathered portion furnishes the cementing material, without which the harder chert-

like fragments will pulverize and blow away. The rapidity with which this softer rock cements is well shown on the Goodland road half a mile north of the quarry. This road is absolutely smooth, the wheel tracks having almost the finish of concrete. It is al-

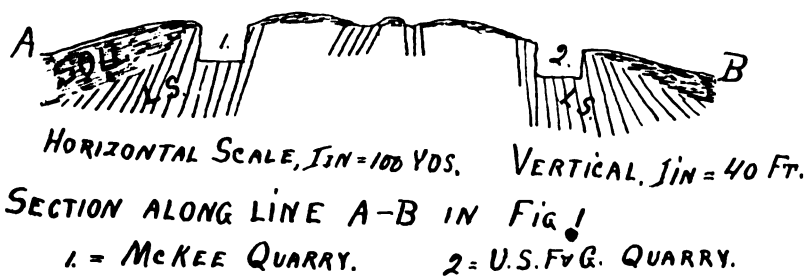

Fig. 25.

most impervious to water, and in July was free from dust. Other roads in the vicinity which have been built longer, but from which the softer rock was excluded, were still rough and dusty.

The plant is very complete, $45,000 being invested in machinery alone. It comprises two steam drills, a steam scoop, a modern crushing outfit, both rotary and "jaw" crushers, quarry trucks and two small locomotives with twenty cars. Besides the engine room, a blacksmith shop and a machine room is maintained. Dormitories and eating houses for the men employed, as well as offices and warehouses, are also located here.

The stripping is done by horse power. Two men, a team and a scraper easily remove the two feet of soil from above the rock. They are followed by the drillers, who put down holes to a depth of 15 feet and blast with dynamite in the evening. The steam shovel follows the drills, scooping up the shattered fragments and dropping them into quarry trucks. These are drawn by steam power to the crusher and ground to fragments 2 inches in diameter. From the hoppers the crushed product is emptied into cars of three yards capacity, 6 to 8 of these cars making a train drawn by a "dinky" engine. Now comes the unusual feature of the work. The company has (in July) about 60 miles of road to build, and teams are hard to get and expensive to maintain. Therefore narrow-gauge tracks are laid along the road to be built and the locomotives haul the rock to its proper place. About 7

miles of track are constantly maintained, with switches, water stations, etc. Each train makes 4 to 5 trips daily, thus placing 150 to 180 yards of crushed rock per diem.

The following samples of rock were sent in to the office for testing at the U. S. Road Laboratory, Washington, D. C.:

No. 1. A grey chert with blue, crescent-like markings, very hard and brittle. About 4 feet of this rock occur exposed in the floor of the quarry.

No. 2. A blue cherty limestone, semi-lithographic, hard and tough. About 30 feet of this rock occur in the quarry, all good and easy to get at.

No. 3. Irregularly interbedded with No. 2 is a crystalline limestone in strata from 2 to 6 inches thick, comprising not more than 10 % of the output.

No. 4. A brown chertlike rock similar to No. 2 except in color.

The capacity of this quarry and plant is limited by the distributing facilities to 150 yards a day, which might easily be increased to 200. Thirty men are employed, and the price obtained for the material is $1.12 per yard, laid down on the roads. The amount of available rock is indefinitely large, but is amply sufficient for any demand that might be made upon it.

The results of the tests made at Washington were as follows:

*Results of Physical Tests of Niagara Limestone from Quarry of the W. F. Goff Stone Co., Kentland, Newton County, Ind.**

Specific gravity	2.7	French coefficient of wear	9.7
Weight per cu. ft. (lbs.)	168.4	Hardness	12
Water absorbed per cu. ft. (lbs.)	.33	Toughness	12
Per cent. of wear	4.1	Cementing value—Dry	19
		Wet	33

"Fairly good resistance to wear for limestone, and fair cementing value. Should give fair results for highway and country-road traffic."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

*For standard of comparison see p. 79.

Chemical Analysis of Niagara Limestone from Quarry of the W. F. Goff Stone Co., Kentland, Newton County, Ind.

	Per cent.
Alumina (Al_2O_3) and iron oxide (Fe_2O_3)	.75
Lime (CaO)	48.65
Magnesia (MgO)	3.49
Phosphoric acid (P_2O_5)	.10
Insoluble in hydrochloric acid (fine silt)	5.13
Loss on ignition	41.64
Total	99.76

BENTON COUNTY.

Area in square miles	410
Population in 1900	13,123
Miles of public roads	775
Miles of improved roads	230
Percentage of roads improved	30
Miles improved with gravel	230
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$2,500
Total original cost of improved roads	$487,500
Annual cost of repairs per mile on gravel roads 5 years old	$90
Miles of improved roads (gravel) built in 1905	10
First improved roads built	1880
Proportion of improved roads built since 1895	25%
Satisfaction of farmers with investment in improved roads—	Generally good
Authority	Lemuel Shipman, County Auditor

Gravel in Benton County is either (a) morainal or (b) "water gravel" transported from the moraines and buried beneath a subsequently formed soil. There are some insignificant beds in "aprons" out in front of the morainal hills and very slight deposits in a few of the stream beds. Extending almost entirely across the county from east to west, and occupying the north central portion, there is a range of low hills consisting of mounds of greater or less length, generally 100 to 600 yards. These hills are largely sand, but a considerable percentage of gravel is mixed with the finer material, sometimes scattered in it, but often in strata from 2 to 6 feet thick. The gravel is nearly always quite uniform in size, and is of the fine, sharp variety generally considered best for road material. A number of pits have been opened in these hills and much gravel has been removed. The better gravel

and the greater quantity is in the eastern hills; farther west they run into sand. The following sections and estimates show the approximate quantity of gravel in the moraine and its manner of deposition:

No. 1.—Section of Gravel Hill, on Big Four Railway, three and one-half miles Northwest of Fowler.

		Feet.
1.	Soil	6" to 2½
2.	Gravel and coarse sand	6
3.	Sand	4+

This deposit measures some 220 yards in length, by an average of 50 in width. The gravel runs out both ways and will average, of workable material, about 3 feet in thickness. The deposit is very irregular, but contains easily 11,000 yards of available gravel.

No. 2.—Section of Deposit half a mile Southeast of No. 1, on Railwag.

		Feet.
1.	Soil	2½
2.	Gravel and sand	5+

This is a small deposit, probably not over 3,000 yards.

No. 3.—Section of an Abandoned Pit, 300 Yards East of No. 1.

		Feet.
1.	Soil	6" to 1
2.	Gravel	2 to 4½

Between No. 1 and No. 3 there extends a continuous sheet of gravel, rather irregularly bedded and from 2′ to 4′ in thickness. There are probably 10,000 yards in this bed, but it is scattered over so much ground and is under so much soil that it can not be profitably worked.

Mount Gilboa Section, 8 Miles East of Fowler.—This is by long odds the best pit in the moraine. It covers, as opened, about three acres; but test holes show that the entire hill, almost 400 yards long and 60 to 120 yards wide, is made of gravel. In the pit that has been worked 20 feet of gravel and sand in about equal proportions are exposed. I am told that a hole has been sunk 20 feet farther down and was still in gravel. Towards the bottom the sand disappears and leaves an excellent road material. In this ridge there are not less than 250,000 yards of gravel, of

which practically all can be worked; and the probabilities are that twice this amount may be located.

In Gilboa Township, 1/4 mile north of schoolhouse No. 7, there is a gravel pit from which 5,000 yards of gravel have been removed, and which contains probably 6,000 to 8,000 more. The gravel is poor, being sandy.

Two hundred yards east of schoolhouse No. 2, in the same township, a similar deposit exists, with probably 7,000 yards of poor gravel available.

In Richland Township, east of Earl Park, the ridges are sandy. There is no single workable deposit here. None with more than 1,000 yards in it were found, but a number of little pits might be opened. The stripping is not heavy, but would hardly pay. A mile and a half west of Earl Park there is a considerable deposit of gravel (6,000 yards), but it is very sandy and of little value.

Four miles east of Fowler, in S. E. 1/4 of Sec. 8, there is a bed of excellent gravel, about 5,000 yards, mentioned because of its accessibility and distance from other deposits.

A well section two miles south of Mt. Gilboa showed 15 feet of gravel under 8 feet of soil. I was unable to find gravel at 10 feet farther than 20 feet from the well, so the deposit must be small. North of this hill region there is no gravel in reaching distance. I was unable to find a well section showing any gravel at all, and the few test holes in most favorable localities were without results.

South of the hill land there is a belt of low country, from 3½ to 6 miles in width, where no gravel occurs. This is a black muck soil; and twenty well sections here showed "hardpan" directly under the muck. South of this belt there is a narrow belt of somewhat higher ground, perhaps 50 yards wide at its eastern end and 300 at its western. This belt extends half way across the county from N. E. to S. W. in a very irregular, winding course. It is broken by cross valleys here and there, but its general outline is plain. This upland belt contains gravel, but at scattered intervals. The material is of excellent quality, water transported and free from sand. It seems to be a flat, low eskar.

Beginning at the eastern end, the first deposit is on the Templeton farm, in the southeast corner of Fowler. A section of his well shows:

Section on Templeton Farm, near Fowler.

		Feet.
1.	Soil	8
2.	Loam	4
3.	Clay	3
4.	Gravel	15

The soil thins out rapidly in all directions; 200 yards south of the well 8 feet of gravel occurs under 4 feet of soil; 200 yards west, 8 inches of gravel; 1/4 mile east and 100 yards north it runs into sand. A number of holes in various places show a probable extent of the bed as 20,000 square yards, with an average thickness of 16 feet. There are here at least 100,000 yards of workable, excellent gravel.

Section in John W. Cooper's Pit, Grant Township, Section 8.

		Feet.
1.	Soil	4 to 6
2.	Gravel	10 to 14

This bed extends east 100 yards, north and south 120 to 150 yards each, and peters out 150 yards west. The average thickness of the gravel here is 6 to 8 feet under 2 to 6 feet of soil. The gravel is very irregular, and no accurate estimate of the amount present can be given. There may be 100,000 yards of gravel in this deposit and there may be no more than 60,000.

On the Dils land, 2½ miles west of the Cooper pit, there is a smaller deposit, perhaps 15,000 yards of good gravel under 3 to 5 feet of soil.

The Campbell pits, 1 mile S. W. of the Dils pit, contain probably 20,000 yards of gravel yet remaining. This is under 3 to 6 feet of soil and contains so much water that the gravel must be pumped out.

The Perigo pit, on the Cook farm, in section 18, Hickory Grove Township, exposes very well a typical gravel deposit of the southwestern part of Benton County. Here under 6 feet of soil there are 14 feet of gravel of excellent quality. It lies in a low ridge, which must be regarded as a worn down morainal hill, for the gravel is mixed with sand and boulders to an extent unlikely in material that had been much carried about by water. Like all other gravel deposits in this vicinity, however, it thins out; borings and test holes, as well as wells, within 200 yards show only a few inches of gravel.

Generally speaking, the L. E. & W. Railway marks the southern limit of gravel in Benton County in its southwestern corner. None of the wells show more than a few inches; and all road material is taken either from Warren County or the pits mentioned above. On the eastern side of the county, however, the low ridges which contain most of the gravel in the county again appear. Two miles south of Oxford in one of these ridges a pit shows 6 to 10 feet of soil with from 12 to 18 feet + of gravel underneath. Three thousand yards are taken annually from here; but owing to the irregularity in thickness of the deposit no close estimate can be made of its content; it is safe, however, to put it at 100,000 yards.

Five miles east of No. 15, in Bolivar Township, one-half mile east of Templeton, Pine Creek cuts through a small ridge and exposes a gravel bed about 6 feet thick under 2 to 4 feet of soil. The deposit is not large, probably not over 20,000 yards altogether, of which 15,000 yards are accessible. Three miles north of here, near Aydelotte P. O., is a smaller bed, about 5,000 yards probably, of poor gravel.

WHITE COUNTY.

Area in square miles	500
Population in 1900	19,138
Miles of public roads	750
Miles of improved roads	143.5
Percentage of roads improved	19.1
Miles improved with gravel	80.5
Miles improved with crushed stone	63
Average original cost of gravel roads per mile	$2,000
Average original cost of stone roads per mile	$2,300
Total original cost of improved roads	$305,900
Annual cost of repairs per mile on gravel roads 5 years old	$85
Annual cost of repairs per mile on stone roads 5 years old	$90
Miles of improved road (gravel) built in 1905	15
Miles of improved road (stone) contracted for 1906	12.5
First improved roads built	1882
Satisfaction of farmers with investment in improved roads	Good
Authority	J. L. Ackerman, County Auditor

In White County gravel is very scarce. The whole northern two-thirds of the county, extending about to the Pennsylvania Railway, is without gravel except along the Tippecanoe River, and even here the exposures are so deep (under 30 to 40 feet of

sand and clay) that it can not be profitably worked. This area is a monotonous sand plain, small dunes rising here and there, with long stretches of flat, swampy lowlands between. The southwest corner of the county, extending east to the river and north to the Pennsylvania Railway, is somewhat more fortunate. In all parts of the county, however, except in the vicinity of Brookston, a coarse sand is often used upon the roads. It is poor material, but it is the best to be had.

The largest deposit of gravel in the county is that lying just across the Tippecanoe River from Monticello. It is a terrace, filled in upon the inner bend of the river when the stream carried more water than at present. There are here nearly thirty feet of sand and gravel interstratified and in some places thoroughly mixed. The fact that the deposit was made from running water is plainly shown by the numerous cross-beddings of the sand layers and an apparent dragging out in the direction of the stream flow. As one goes back from the present stream bed toward the bluffs the sand and gravel gradually thin out, and on the edge of the terrace the gravel disappears almost entirely. Almost ninety acres are comprised in this flood plain, nearly all of it being underlain with gravel or sand in varying proportions.

In spite of the irregularity of deposition of sand and gravel, three tolerably definite layers can be discovered, with considerable variation within themselves, but on the whole quite distinguishable from the rest. The upper ten feet of the terrace is a good gravel, remarkably "clean" except for a foot of soil on the top. The grains are small, 95 % being less than one-half inch in diameter. Immediately under this layer is a stratum of coarse gravel and boulders 7 to 9 feet thick. Here the fragments vary from 3 inches to 10 inches in diameter, with an occasional boulder 2 feet or more across. Underneath this coarse deposit comes 8 or 10 feet of sand, nearly everywhere free from gravel. It is a very uniform stratum and extends down to hardpan. The section shows:

Section of Gravel Deposit near Monticello.

	Feet.
1. Clean gravel, no sand	10
2. Coarse gravel and boulders	7 to 9
3. Sand	8 to 10

The peculiar alternation of sand and fine gravel, with a much coarser deposit between, would indicate two periods of comparative weakness of current, with a much stronger flow between.

In Sec. 25, T. 27 N., R. 3 W., two and one-half miles northeast of Monticello, there is an abandoned gravel pit at the edge of the Pennsylvania Railway right of way. Here under five feet of clay occurs four feet of very poor gravel, almost quicksand. Fifty yards east of the pit eight feet of sandy clay were encountered. The well section 300 yards north of here showed a few inches of gravel under 14 feet of mixed sand and clay.

This section may be taken as the type for all of Jackson Township. Some 50 holes were sunk, all of which showed sand or clay. Farmers say that their wells are put down through sand or clay to a depth of 30 to 40 feet before striking gravel, and often none at all is encountered.

In Cass and Liberty townships, north of Jackson, practically the same conditions exist, except that the clay has disappeared. Here and there a small pocket of coarser sand occurs, but it is unfit for road stuff. In fact, almost all of White County north of the Panhandle R. R. is a sand prairie. Monon, Honey Creek, Big Creek, Liberty, Cass, Jackson and Princeton townships are covered with sand or sandy clay varying from three feet in thickness about Monon to 50 feet at Norway. In several localities in these townships pits have been opened at a cost of $100 or more, yielding 200 to 500 yards of very poor gravel, 70 % of the total material taken being sand. In all this part of the county there is absolutely no gravel worthy of consideration as road material away from the river. Here in the second terrace, beds of gravel of fine quality are interlaid with the sand. The scarcity of boulders leads one to expect that little gravel will be found; for boulders and gravel are usually intimately connected, and both are nearly always absent from a region of sand and sandy clay.

Brookston and Vicinity.

The village of Brookston, in the southern part of the county, R. 4 W., T. 25 N., lies in the loam prairie, with morainal ridges to the north and east. These ridges are mixtures of gravel and sand, the former at the bottom. East of Brookston two miles is

the Woods pit, showing 4 feet of gravel under 6 to 8 inches of soil. This pit is in the top of a north-and-south ridge, which throughout shows about the same material, the soil covering varying in thickness from 6 inches to 4 feet, the gravel from 4 to 8 feet. On the west side of the ridge a poorly defined apron shows 2 feet of gravel under 4 to 6 feet of loam. The "big ditch" ½ mile west shows 4 feet of gravel in its bottom. One-half mile east of the Springboro schoolhouse is a pit, also in the top of ridge, which contains 12 feet of sandy gravel under 6 inches to 2 feet of loam. The gravel is fair in quality and accessible. This ridge shows throughout a mixture of gravel and sand, most of it fair road material. Almost a mile east of this ridge is another, also containing gravel, usually in small pockets. The "aprons" of these ridges are poorly defined and contain little clean gravel. On Moore's Creek just southeast of Brookston the stream in its cutting through the glacial debris shows the variability of the deposits. Little pockets of sand, gravel and clay succeed each other and mingle in all sorts of percentages.

Seven and one-half miles west of Brookston in Sec. 17 a large pit in the ridge shows a fine gravel irregularly deposited. From this pit six miles of road have been built, almost exhausting it. The ridge, a quarter of a mile long, shows more or less gravel in its whole length; but the material is pockety, and hence the opening of a pit is uncertain. A section in the pit shows 9 feet of gravel under 1 to 3 feet of soil. Ten test holes show 1 to 8 feet of gravel, rapidly thinning out.

In the northeast quarter of Sec. 18 gravel occurs in a low ridge in a strip not over 50 feet wide, being 4 to 8 feet thick under 4 feet of soil. Just east of this pocket, in the ditch near the road, 10 feet of gravel is exposed, but it thins out so rapidly that probably not more than 1,000 yards are available.

One and a fourth miles southwest of the above pit is a large bank from which 20,000 yards of gravel have been removed by a dredge. The gravel is remarkably clean, uniform in size and cementing well. The section shows 30 feet of gravel under 3 to 5 feet of soil. Luckily, the pit was opened just where the gravel was thickest, for drillings at various points from 10 to 50 yards from the hole showed from 6 to 18 inches of gravel. This de-

posit is about worked out, and there does not seem to be a workable bed very near.

In Section 31, R. 6 W., almost at the Tippecanoe County line, is another bed of gravel almost exactly like the one above described. In August, 1903, some 20,000 yards of excellent gravel had been dredged out, with probably as much more still to be removed. Here again the gravel was not more than 18 inches thick at a distance of 20 yards north and 100 yards south, being altogether absent at several intervening points. The gravel removed is of fine quality, but the irregularity of deposition adds an element of risk to the opening of pits.

Near the middle of the west side of Sec. 29 is an undeveloped bed of gravel about 200 yards in length and 50 to 75 yards in breadth. Five drillings here showed ten feet of gravel, but as many between the first five showed less than one foot. The deposit is very irregular; there may be anywhere from 2,000 to 15,000 yards of gravel here.

In Sec. 35 (26 N.—6 W.), West Point Township, two miles from the Benton County line, there is a bed of wash gravel containing possibly 5,000 yards of excellent material. At numerous other points in Prairie, Round Grove and West Point townships there are small beds of gravel, rarely containing more than 600 yards. In the aggregate, however, these small deposits have been instrumental in building much road.

In several areas in the above townships where gravel is inaccessible there are plenty of boulders along the roads to macadamize them well if properly crushed. However, there is a prejudice against the roughness of such roads when new which operates against them. North of Wolcott in Princeton Township two miles of such road is in excellent condition and shows what might be done with the despised "niggerheads." It would seem at any rate profitable to make the foundation of the road of such material, reserving the scarce gravel for top covering.

Road Making Stone in White County.

One mile south of Monon in White County is the stone quarry and crushing plant of Edward Hely. The quarry lies in the middle of a little basin some three miles in diameter, surrounded by

ranges of low sand hills. Within a mile of the pit the soil is not more than 3 feet deep. Farther toward the hills the soil becomes thicker. Cutting through the basin surface at its northern end is Monon Creek, which cuts into the limestone about five feet. For two miles up the stream from the Monon Railway the rock is continuously exposed either on the sides or in the bottom of the stream, being nowhere covered by more than 3 feet of soil. Down the creek the stone crops out at intervals for two miles, but is usually covered with soil. The same rock crops out east of Monon 3 miles, but has not been extensively quarried. Every well within a radius of three miles strikes this rock, which is everywhere near enough the surface for profitable quarrying except where sand hills enter the depression.

The stone, a silicified limestone of Niagaran age, occurs in the Hely quarry in two distinct layers, sometimes grading into each other, but usually separated by a thin sand stratum. The upper layer is about three feet thick, brown and siliceous. It is hard and almost free from fossils. This rock is allowed to fall into the crusher, but its use is not favored upon roads. The percentage of silica is so great that the crushed fragments crumble and pulverize too easily, and there is not enough lime in the rock to cement the particles.

The lower layer of rock is gray to white, hard and somewhat siliceous. It occurs in the quarry in a stratum about 11 feet thick, with few bedding planes and is irregularly stratified. Both this stratum and the one above are blocked off by numerous jointing planes. This lower stratum is very fossiliferous in places, Orthoceras sp (?) fragments being most in evidence. When these are very numerous the silica impairs the road-making value of the stone. As a whole, however, the material is very good, and its accessibility renders this stone field a valuable asset of the county.

Section in Hely Quarry.

	Feet.
1. Soil	1½ to 3
2. Brown siliceous limestone	3
3. Gray to white limestone	11

Samples from the quarry were sent to Washington for testing at the U. S. Road Laboratory, the results of the tests being as follows:

*Results of Physical Tests of Niagara Limestone from the Quarry of Edward Hely, near Monon, White County.**

Specific gravity	2.7	Hardness	7.5
Weight per cu. ft. (lbs.)	168	Toughness	9
Water absorbed per cu. ft. (lbs.)	1.04	Cementing value—Dry	29
		Wet	43

"A fairly hard and tough rock with a good cementing value. Suited to suburban and highway traffic. Material not sufficient for French coefficient and per cent. of wear."—Page.

The crushing plant is modern and convenient in every detail. Steam drills are used to penetrate the rock, steam power hoists the cars from the quarry to the crusher. The Gates rotary machine is the type of crusher employed. The fragments are passed through screens of 2½, ⅞ and ½ inches aperture, pieces larger than 2½ inches being automatically returned to a smaller crusher.

The usual force of men employed is 30, more being required in busy seasons. With 30 men 400 yards of crushed rock can be turned out in a working day of 10 hours. In large lots (more than a carload) the product is placed on the cars for 57 cents per yard.

CASS COUNTY.

Area in square miles	420
Population in 1900	34,545
Miles of public roads	988
Miles of improved roads	213
Percentage of roads improved	21.5
Miles improved with gravel	202
Miles improved with crushed stone	11
Average original cost of gravel roads per mile	$1,700
Average original cost of stone roads per mile	$2,500
Total original cost of improved roads	$370,900
Annual cost of repairs per mile on gravel roads 5 years old	$75
Annual cost of repairs per mile on stone roads 5 years old	$70
Miles of improved roads (gravel) built in 1905	8.5
Miles of improved roads (stone) built in 1905	2
Miles of improved roads (gravel) contracted for 1906	4
First improved roads built	1861
Miles of improved roads built since 1895	152
Satisfaction of farmers with investment in improved roads	Good
Authority	J. F. Grable, County Commissioner

*For standard of comparison see p. 79.

Cass County lies near the center of the fourth tier of counties, with the city of Logansport as its county seat. South of the Wabash River, which runs nearly east and west across the county, the surface is nearly plane, composed of till, usually sandy. The northwestern part of the county is also sandy till, with the extreme northwest corner in the great sand area of northwestern Indiana. The central half of the county is composed of the Erie-Saginaw moraine.

The rivers Wabash and Eel expose gravel in their bluffs and limestone in the bottoms throughout almost their entire course in this county. The bluffs of the Wabash are 30 to 60 feet high and are practically solid gravel. Here and there the gravel runs into sand, and sometimes the till above is 15 feet thick. But as a rule the heavy blue clay that marks the bottom of the till is less than 10 feet below the top, leaving 30 to 45 feet of gravel immediately overlying the limestone. This limestone is exposed almost everywhere along the Wabash and plentifully along the Eel, often occurring in thick ledges with no stripping. The river bottom is gravel and sand one or two miles wide, and there are numerous mounds of pure gravel rising 4 to 8 feet above the general level of the valley floor. Wherever the limestone is not too close to the surface a stripping of 2 to 4 feet reveals gravel in this bottom, extending down 4 to 10 feet.

At Lewisburg, six miles east of Logansport, the Wabash Valley interurban line has a large gravel pit typical of those along the river bluffs. It is in the south side of the valley and consists of 30 feet of good gravel under 4 to 8 feet of till, yellow at the top, blue at the bottom. There is practically no limit to the amount of gravel in pits like this.

One-half mile west of the above pit there is an older one from which gravel has been taken for roadstuff for twenty years.

West of Logansport about two miles the gravel thins out and the till thickens. At Lake Cicott the till and sand ridges cover the gravel to a depth of twenty feet, a stripping so thick as to preclude the opening of large pits.

The entire southern part of the county south of the Wabash is a till plain, very smooth, broken only by the valleys of Deer Creek, Rock Creek and their tributaries. The till is mainly clay, with some sand; and in places, as the vicinity of Walton, the sand pre-

dominates. The clay or sand runs from 8 to 25 feet in thickness, with gravel underlying. The stripping is too heavy in most places to allow the opening of gravel pits; but some small ones are worked where the till thins out locally. The main gravel resource of this part of the county is along the streams. Deer Creek and Rock Creek cut down through the till and reveal the gravel below.

At Walton there is no "workable" gravel. Some miles of road have been built in this vicinity of yellowish quicksand, but they don't pack. In this region some rock road has also been built; and in view of the poor quality of the gravel more should be constructed of stone.

Galveston and Vicinity.

Galveston lies in the till plain near the south and east boundaries of the county. The surface soil, 8 to 12 feet deep, is clay or sandy till. Below this comes gravel 10 to 40 feet deep. The valley of Little Deer Creek cuts through the overlying till and exposes gravel nearly everywhere. There are numerous small pits in the vicinity and one large one a mile southeast of Galveston, from which five or six miles of the county line road was built in 1904. Eight miles west of Galveston the Wolf pit on Deer Creek furnished gravel for the rest of the road. There is plenty of gravel in this vicinity, but it is not accessible except along the streams.

Royal Center and Vicinity.

The extreme northwestern part of Cass County is a till plain, differing from the southern part in being largely sand, with some few clay knolls. Between the sand and the morainic belt there is a narrow till plain mostly clay at the top. Sections of several wells near Royal Center show:

General Section of Wells near Royal Center.

		Feet.
1.	Clay or sandy clay	2 to 8
2.	Gravel or quicksand	3 to 7
3.	Blue till	6 to 40

Many of the wells stop in the gravel just over the blue till, but some of them find their water in small gravel pockets within the

till. The surface gravel pits are here small and poor, but the deeper dredge ditches get down to an excellent water gravel that can best be removed by pump or dredge.

Northern Portion of the County.

At Lucerne, in the north-central part of the county, the gravel is sandy and not at all suitable for roadstuff. Here the experiment is being tried of crushing "niggerheads" or boulders and using the product in the roads. No judgment can be formed as to the packing quality of this sort of macadam because the roadbed has been down for only a few months.

In Section 28, Bethlehem Township, in the north-central part of the county, a gravel pit is maintained in a morainal knoll where the till is thin, whose product is used by the county for road repair. Some 500 to 1,000 yards are taken out annually.

Adams Township, in the northeast corner of the county, is without gravel, the surface being sand or sandy clay. It is the only part of the county where no gravel can be had without excessive hauling.

In the great morainic belt of the county gravel is not obtained in "workable" quantity. There are numerous small pits, from 1,000 to 5,000 yards capacity, which relieve the situation and furnish enough gravel to build and repair the principal roads. This gravel is found in the ridges where the heavy clay has been partly removed by erosion.

MACADAM LIMESTONE IN CASS COUNTY.

The Casparis Stone Company, headquarters at Kenneth, Ind., two miles west of Logansport, crushes the Niagara limestone exposed in the bluff at that place for roadstuff. This company works two quarries, one at Kenneth and one two miles west of the first. The stone is exactly the same in the two places and is employed for the same purposes. The Kenneth quarry is the older and better known. It covers, both the older part and the portion now being worked, some 30 acres. The section shows:

Section at Kenneth Stone Quarry.

		Feet.
1.	Sandy clay or clay	6 to 12
2.	Blue limestone	26 to 30
3.	Brown dolomite	30 to 45

The ledges run from 6 inches to 18 inches in thickness for the limestone, from 12 inches to 30 inches for the dolomite. The general dip is 2° or 3° to the north. Only the blue limestone is used for macadam, the dolomite being crushed for use in the steel plants of Chicago as a flux.

A sample from the quarry was sent to the U. S. Road Laboratory for testing. It was not sufficient in quantity to show the percentage of wear, hardness and toughness tests. The results of the other tests were as follows:

Results of Physical Tests of Niagara Limestone from Quarry of the Casparis Stone Company, Kenneth, Cass County.

Specific gravity	2.65	Water absorbed per cu. ft. (lbs.)	1.31
Weight per cu. ft. (lbs.)	165	Cementing value—Dry	11
		Wet	47

"Not enough for abrasion, and no piece large enough for hardness and toughness tests. Develops a good cementing value."—Page.

A chemical analysis of a sample of the stone, made at the same laboratory, resulted as follows:

Chemical Analysis of Niagara Limestone from the Quarry of the Casparis Stone Company, near Logansport, Cass County.

	Per cent.
Alumina (Al_2O_3)	.25
Iron oxide (Fe_2O_3)	.24
Lime (CaO)	53.10
Magnesia (MgO)	.61
Insoluble in hydrochloric acid	4.00
Loss on ignition	41.65
Total	99.85

The crushing plant at Kenneth is very complete. Small locomotives push the loaded cars to the foot of the incline and steam power carries them to the hoppers. Gates gyratory crushers grind the rock and automatic screens separate the product. The plant presents no new features, but is the largest in northern Indiana.

At the new quarry two miles west of Kenneth two crushers are in use, and the plant is much like the other. From the superintendent the following data were obtained, applying to both quarries:

Men employed	250
Capacity (tons per year)	150,000
Price (ton)	$0.50

The total capacity of the crushers is placed at 600,000 tons per year, of which 150,000 tons are macadam.

A small crusher in Logansport is used in crushing dolomite for concrete work about the city. Very little macadam is produced.

At Georgetown, 6 miles west from Logansport, a township crusher grinds some blue limestone for road repair work. It is a small jaw crusher with a capacity of 40 yards a day when it works.

MIAMI COUNTY.

Area in square miles	375
Population in 1900	28,344
Miles of public roads	1,120
Miles of improved roads*	504
Percentage of roads improved	45
Miles improved with gravel	504
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$2,000
Total original cost of improved roads	$332,000
Annual cost of repairs per mile on gravel roads 5 years old	$104
Miles of improved roads (gravel) built in 1905	8
Miles of improved roads (gravel) contracted for 1906	10.5
First improved roads built	1870
Satisfaction of farmers with investment in improved roads—	Generally well satisfied.

Authorities—

C. W. Macey	County Auditor
Peter Kelly	Engineer in charge of construction

*One hundred and six miles built by contract, 398 miles by working out road tax. The cost of the latter estimated at $300 per mile.

Miami County lies just east of Cass, with Peru for its county seat. Both the Eel and the Wabash rivers cross it, and the Mississinewa comes in from the east. Pipe Creek is the largest stream in the southern part of the county. The Wabash River approximately divides the county into two regions of widely varying relief and surface soil. The area to the north is almost entirely morainic,—the Erie-Saginaw lobe, with its characteristic knolls of clay; the part to the south is a sandy or clayey sand till plain with little relief.

Macy and Vicinity.

In the northwestern part of the county, where the till plain of Fulton County enters, gravel is abundant, usually at slight depths, four to six feet. The topography is one of low bogs and sandy

knolls, and underneath the soil in the bogs the gravel occurs. It is a water-bearing stratum and can not be extensively worked except by pumps. The deeper ditches in this vicinity get down to the top of the gravel.

Elsewhere in the northern half of Miami County gravel is not abundant except along the streams. The morainic knolls contain small lenses of gravel—1,000 to 5,000 yards—but the great gravel bed lies entirely underneath the moraine at depths usually greater than twenty feet. This gravel deposit is shown by well sections to run from 30 to 50 feet in thickness. A typical exposure of this sheet occurs on Eel River near Denver. The stream has incised itself twenty or thirty feet, and consequently reveals the underlying gravel. The L. E. and W. Railway has here a gravel pit practically no stripping. Fifty yards to the west the same sheet is opened by road contractors with very little stripping.

Eel River throughout its whole course in this county exposes the covering fifty acres. The material is an excellent fine gravel, uniform in quality. It occurs to a depth of at least 25 feet, with great sheet of gravel, and the lower courses of the tributary creeks do also. An abundance of good material is offered here with slight expense for working.

At Gilead, in the northeastern part of the county, the gravel comes from the knolls where erosion has removed much of the till. It is not a first-class material and the pits are too small to be termed "workable." Still, they are sufficiently close together to allow the building of all roads desired.

Southern Portion of the County.

The south half of the county is a till plain with a sandy clay as the surface soil. The plane surface is broken here and there by clay knolls and by stream valleys. Away from the streams good gravel is extremely scarce in this area. A coarse quicksand is taken from the knolls and used for roads in some localities. Wells show an excellent gravel at a depth varying from 15 to 30 feet.

Amboy is a village in this southern till plain. Here the surface clay is ten to twenty feet thick where erosion has not removed it. Then comes two or three feet of quicksand, with a substratum of twenty to forty feet of an excellent gray water gravel.

Pipe Creek in the vicinity of Amboy has removed enough clay to allow the gravel to be gotten at. Pumps are used for the large pits, a little branch furnishing water. There are some half dozen pits in this vicinity, all containing the finest sort of road-making gravel. Some little surface gravel is taken from the knolls in this region—a foolish procedure when good gravel is so close at hand.

In Clay and Washington townships, also in this till plain, pumps are used to get at the great underlying gravel sheet.

At Bunker Hill the creek itself gets down into gravel, which is removed by hand when the water gets low enough. A pump would probably be better. Some surface gravel is removed from the knolls, but it is not of first-class quality.

The Wabash River bluffs in Miami County rarely contain gravel. They are for the most part clay, 25 to 40 feet high, overlying a 2 to 4 feet sand stratum. Underneath this comes gravel, often 60 feet deep and sometimes not more than three or four where the rock comes close to the surface. This part of the county depends for its gravel upon the river bottom or alluvium. This is practically all gravel, the city of Peru being built upon gravel and largely paved with gravel. It is so good and so plentiful that there is no demand for macadam, despite the fact that a good quality of limestone outcrops in the city limits. A fairly well equipped crushing plant at this place is rapidly falling to pieces, there being no sale for its product.

Mr. Kelley, the County Surveyor, says that gravel for road building need not be hauled more than three miles anywhere in the county, and that the average haul is far less than that. By utilizing the small deposits of the moraine and getting out the gravel along the streams in the southern part of the county I have no doubt that Mr. Kelley is right.

Summary—Situation fair; material, abundant; road sentiment, weak.

WABASH COUNTY.

Area in square miles	418
Population in 1900	28,235
Miles of public roads	600
Miles of improved roads	200
Percentage of roads improved	33.3
Miles improved with gravel	200
Miles improved with crushed stone	None
Average original cost of gravel roads per mile*	$750
Total original cost of improved roads	$150,000
Annual cost of repairs per mile on gravel roads 5 years old	$90
Authority	W. S. Davis, County Auditor

*"Most roads are being improved by townships and when they meet the requirements these roads are accepted by the county commissioners. They are then kept in repair by the county." W. S. D.

Wabash County lies east of the middle of the State in the third tier from the north. Wabash is the county seat. Two-thirds of this county is till plain, the only morainic portions being in the northwestern corner, a lobe in the northeastern part and the terminus of the Mississinewa moraine in the southeastern corner. The Wabash River extends across the county and Eel River cuts across the northwestern corner.

Gravel is not very abundant in this county, or perhaps one had better say not very well distributed. The moraines are of heavy clay, usually 35 to 40 feet thick and very seldom less than 20 feet. Eel River cuts through this clay and exposes the gravel underneath; and the narrow strip of bottom along Eel River is practically the only gravel in the county except that of the Wabash terraces. These terraces are three in number. The highest is a rock terrace, marking the preglacial valley, varying from 1 to 2½ miles in width. This valley became filled to a depth of 5 to 20 feet with alluvium, mainly gravel, with some sand and a little clay. This forms the second terrace into which the river has incised itself. The third terrace is of very recent alluvium, mainly sand with gravel bars. It is in the second terrace that most of the gravel pits are found, and the material is not of very excellent quality.

South of the Wabash River the drift is thin, usually not more than thirty feet. It consists of clay almost exclusively, yellow at the top for 18 to 25 feet and heavy blue till at the bottom 2 to 6

feet. A noteworthy exception is the Lafontaine region, where the drift is at least 200 feet thick, with 25 to 30 feet of clay overlying the gravel.

In the Mississinewa moraine and the one in the northwestern corner of the county small gravel beds of 500 to 1,000 yards are found in the knolls. These small deposits are numerous enough to gravel the main roads,—a fortunate thing, as Eel River is the only stream large enough to cut through the heavy clay.

Lafontaine and Vicinity.

Lafontaine, in the southern part of the county, lies in the till plain. Here the surface soil is yellow clay 20 feet thick, with 4 to 6 feet of blue till underneath. The oil wells of this vicinity show beneath the till 200 to 300 feet of gravel, with some interbedded clay. This extraordinarily deep drift is supposed to occupy the valley of a preglacial stream. Along the little creek in Lafontaine, where much of the till has been removed by erosion, this gravel can be reached at a depth of 4 to 6 feet. Much of the gravel used in this vicinity comes from this sheet, but some stream gravel is also used. The little knolls are occasionally worked for a coarse sand that is placed upon the roads, and once in a while some very fair gravel is found in these sand deposits. They are all small, however, and totally inadequate for road building.

At North Manchester, situated on the moraine, there is no gravel fit for roadstuff. A coarse sand is sometimes employed, and the little gravel bars in the river.

At Lagro, on the Wabash River, some gravel is furnished by the river terraces and gravel bars. There is much rock exposed here that might be pressed into service.

Macadam Stone in Wabash County.

The firm of Thos. Bridges's Sons has an excellently equipped plant on the river bluff in the southern part of Wabash. The stone is Niagara limestone, quarried to a depth of 18 to 20 feet. The portion quarried can readily be separated into two classes—the upper 12 to 14 feet being flinty, the lower 4 to 6 feet a clean limestone occurring in ledges 6 inches to 20 inches thick. The section shows:

Section of Quarry of Bridges Sons.

		Feet.
1.	Gray to white limestone, with much chert	14
2.	Grayish-buff limestone, little chert	4—6
3.	Blue limestone, 4-in. to 16-in. ledges	2
4.	Blue shale "soapstone"	14

The plant is the usual type, with Gates's gyratory crushers (Nos. 3 and 5), bins, automatic screens, etc. Mr. Frank Bridges gave the following data in regard to the plant:

Men employed	20 to 25
Capacity (yards daily)	350
Price per yard, average	$0.70

The product is largely shipped to nearby points for use in concrete work, macadam, asphalting, etc. Some is used at home in repairing and building streets, curbing, etc. The firm has a spur from the Big Four track.

Wabash Stone Company.—This company, made up chiefly of Ft. Wayne men, has its quarry three miles west of Wabash in the river bluff on a spur of the Wabash Railway. The rock is Niagara limestone. The plant is the usual type—steam drills, Gates's gyratory crusher (No. 5), elevator, screens, etc. The section here shows:

Section at Quarry of Wabash Stone Company.

		Feet.
1.	Blue or buff limestone, hard, tough	14
2.	Buff limestone, building material	8
3.	Blue shale	117

The superintendent gave the following data:

Men employed	20
Production, daily for 9 months in year (yds.)	150
Price (average)	$0.70

The price in this case is approximate. The people owning the plant are contractors and use much of the product in their own work.

Besides these two modern plants a small jaw crusher runs intermittently at a little quarry one mile west of Wabash. It employs 5 or 6 men when in operation and grinds out possibly 40 yards a day. It uses the same rock as No. 1 in the section above, the product being used for road repair and concrete work.

Plate IV.

(a) Stone crushing plant of Thomas Bridges' Sons, South Wabash, Wabash County.

(b) Quarry of Thomas Bridges' Sons, South Wabash, Wabash County.

The roads for two or three miles out of Wabash are usually macadam with gravel top dressing. There is no better rock in the State than the flinty limestone of Wabash for road work. Two streets in the city built of this material have been down eight and ten years, and are as smooth as asphalt and apparently unworn.

Two samples of stone from the Bridges Sons' quarry and one from the quarry of the Wabash Stone Company were tested at the U. S. Road Laboratory at Washington, D. C., the results of the tests being as follows. The average of 192 samples of limestone is also included as a standard of comparison:

Results of Physical Tests of Niagara Limestone from the Quarries of Bridges Sons and the Wabash Stone Co., near Wabash, Indiana.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight Per Cubic Foot, Pounds.	Water Absorbed Per Cubic Foot, Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
Average of 192 samples	2.7	165.7	1.39	5.7	8.7	3.4	11	32 59
Bridges Sons, sample No. 1	2.8	171.5	.43	3.3	12.1	11.5	9	17 21
Bridges Sons, sample No. 2	2.56	159	2.43	4.6	8.7	......	......	41 ......
Wabash Stone Co	2.6	162.2	3.29	3.8	10.5	9.3	10	20 27

Bridges Sons, sample No. 1. "Good resistance to wear for limestone, and fair cementing value. Best suited for highway and country-road traffic."—Page.

Bridges Sons sample No. 2. "About the average resistance to wear for limestone; cementing value fairly good. Should give best results under highway and country-road traffic."—Page

Wabash Stone Co., sample No. 3. "Fairly good resistance to wear for limestone, and fair cementing value. Best suited for highway and country-road traffic."—Page.

Samples from each quarry were analyzed in the chemical department of the same laboratory and their composition found to be as follows:

Chemical Analyses of Niagara Limestone from the Quarries of Bridges Sons and the Wabash Stone Company, near Wabash.

	Sample No. 1. Bridges Sons. Per cent.	*Sample No. 2. Bridges Sons. Per cent.*	*Wabash Stone Co. Per cent*
Alumni (Al_2O_3)	.84	1.00	1.10
Iron oxide (Fe_2O_3)	.51	.25	....
Lime (CaO)	43.65	48.05	41.10
Magnesia (MgO)	4.89	1.81	3.48
Insoluble in hydrochloric acid (silt)	10.03	10.00	18.65
Loss on ignition	40.30	38.59	36.00
Totals	100.22	99.70	100.33

HUNTINGTON COUNTY.

Area in square miles	385
Population in 1900	28,901
Miles of public roads	856
Miles of improved roads	496
Percentage of roads improved	58
Miles improved with gravel	485
Miles improved with crushed stone	11
Average original cost of gravel roads per mile	$2,000
Average original cost of stone roads per mile*	$1,000
Total original cost of improved roads	$981,000
Annual cost of repairs per mile on gravel roads 5 years old	$72
Miles of improved road (gravel) built in 1905	8
Miles of improved roads (gravel) contracted for 1906	3
First improved roads built	1884
Proportion of improved roads built since 1895	1.5%
Satisfaction of farmers with investment in improved roads	Good
Authority	L. C. Ward

*"The stone road has nearly all been built by private work, and consists of isolated patches. No figures are available as to original cost, or cost for annual repair. Cost estimated at $1,000 per mile." L. C. W.

Huntington County, with Huntington as its county seat, lies in northeastern Indiana, the fourth county from the north and third from the east boundary of the State. Its surface is almost plane, the Salamonie moraine in the southeast part being the only very noticeable elevation, and this can not be traced distinctly toward the center of the county. There are two other smaller moraines near the center of the county, but they are of very slight elevation. The drainage of the county is through the Wabash, Little Wabash and Salamonie rivers and their tributaries. The most noteworthy

topographic feature is the valley of the Little Wabash. This stream is not half the size of the Wabash, but its valley is from one to two miles wide and 60 to 80 feet deep, while the larger stream has a valley rarely more than half a mile wide and not over 50 feet deep. This discrepancy is accounted for by the fact that the Little Wabash is supposed to have been the outlet for Lake Erie and associated waters in preglacial times.

The great till plain which makes up three-fourths the surface of this county is composed of clay at the top, 8 to 20 feet thick, gravel or sand 20 to 100 feet deep, as a rule, and a blue till, very dense and compact, 4 to 8 feet thick resting on the limestone. These figures are average, there being wide variations from the river sections, where the whole drift may be not over 50 feet, and in the northwestern part, where the drift thickens to 200 feet. In general the rock is much nearer the surface south of the Wabash than north of it.

As the gravel layer is invariably covered by from 8 to 20 feet of clay in this county there is no gravel exposed anywhere except along the stream escarpments. Here it may be found almost everywhere, and nearly every section of the river townships has a pit of greater or less size. Other gravel occurs along the streams where it has accumulated as alluvium. This material, from its cheapness and abundance, is almost exclusively used for roadstuff. Some of the pits typical of the river bluffs are described below.

Pits of the River Bluffs.

One mile east of Huntington along the Ft. Wayne and Southwestern traction line there is a pit in the river bluff. The section shows:

Section of Pit No. 1.

	Feet.
1. Surface soil and clay	12
2. Gravel and sand	10
3. Yellow and blue till	4+

Just north of the Etna avenue bridge, a mile southwest from Huntington, the Wabash exposes the entire thickness of the drift. The section here shows:

Section of Pit No. 2.

		Feet
1.	Yellow clay, compact	25
2.	Sand	2
3.	Clayey gravel	25
4.	Shale, or shaly limestone	5+

The lower ten feet of Number 3 seems to possess the requisite qualities of road gravel. Huge balls of gravel which broke from the main body and rolled to the bottom in March are still firmly cemented together in September, withstanding severe blows. The material is abundant and easily gotten at.

Another pit characteristic of the river bluffs is located at Happy Hollow, four miles west of Huntington. The traction company obtained much of its ballast gravel from here. The section shows:

Section of Pit at Happy Hollow.

		Feet.
1.	Yellow clay	8
2.	Gravel and sand	12—15

In the vicinity of Markle the till usually extends to limestone, with very small local deposits of gravel. The rock floor of the Wabash valley is here covered by 4 to 8 feet of alluvium, of which at least three-fourths is gravel of excellent quality.

Limestone in Huntington County.

By far the most valuable road material in Huntington County is its limestone. Where it has been tried it has been found excellent and durable, but the abundance of gravel in the localities where the stone is found has operated against very extensive use of the latter. Previous reports of this department have dealt with this Niagara rock rather thoroughly, and but few words are necessary as to its distribution. The outcrops are confined to the channels of the Little Wabash and Wabash rivers, where the drift has been eroded by the streams. On Little Wabash the first appearance of the rock is east of Mardenis, about 3.5 miles east of Huntington. From this locality to the junction with the Wabash the strata are almost constantly in sight. The peculiar domelike structure of the stone, however, sometimes places the strata under 9 to 15 feet of alluvium. On the Wabash the most easterly outcrop of the rock is at Markle, near the edge of the county. This exposure is at the top of a dome, and no further exposures of the

limestone occur on the river until the junction is reached. In several places, however, a blue shale that overlies the limestone appears in the channel. Below the junction of the rivers the limestone is continually exposed for about three miles; then it disappears below some 10 to 15 feet of drift, reappearing a mile farther west. This alternation of outcrop and disappearance is repeated before the stone finally leaves the county. At all of the various outcroppings, which are so situated as to be within reasonable hauling distance of one-third of the county, the limestone is hard, white to buff and apparently good road material. There has been as yet no great effort made to use the limestone on roads. Keefer and Bailey have a crushing plant in the western edge of Huntington, for which Mr. Keefer gives the following data:

Men employed	15
Capacity (per day), yds.	140—160

This firm uses practically all its product in street improvements in the city of Huntington and for concrete work. Their shipping facilities are poor, and no attempt is made to work up a trade with outside points. A sample from their quarry was sent to the U. S. Road Laboratory for testing, the results being as follows:

Results of Physical Tests of Niagara Limestone from Quarry of Keefer & Bailey, Huntington, Ind.

Specific gravity	2.75	Water absorbed per cu. ft..(lbs.)	1.21
Weight per cu. ft...(lbs.)	172	Cementing value—Dry	18
		Wet	36

"Not enough for abrasion and no piece large enough for hardness and toughness tests. A fair cementing value."—Page.

A chemical analysis of a sample of the stone, made at the same laboratory, resulted as follows:

Chemical Analysis of Niagara Limestone from the Quarry of Keefer & Bailey, Huntington, Huntington County.

	Per cent.
Alumina (Al_2O_3)	.71
Iron oxide (Fe_2O_3)	.24
Lime (CaO)	30.40
Magnesia (MgO)	21.04
Insoluble in hydrochloric acid	1.67
Loss on ignition	46.00
Total	100.06

At Markle, Mr. F. A. Brickley operates a quarry, getting out building stone and crushing some of the rock for gravel road repairing. The sentiment in this locality is growing in favor of stone roads.

At Huntington a new concern, the Erie Stone Company, is preparing to go into the business of crushing and shipping the limestone on an extensive scale.

WELLS COUNTY.

Area in square miles	367
Population in 1900	23,449
Miles of public roads	780
Miles of improved roads	452
Percentage of roads improved	57.9
Miles improved with gravel	440
Miles improved with crushed stone	12
Average original cost of gravel roads per mile	$1,800
Average original cost of stone roads per mile	$2,800
Total original cost of improved roads	$825,600
Annual cost of repairs per mile on gravel roads 5 years old	$67
Annual cost of repairs per mile on stone roads 5 years old	$100
Miles of improved road (gravel) built in 1905	75
Miles of improved road (stone) built in 1905	1
First improved roads built	1881
Proportion of improved roads built since 1895	42%
Satisfaction of farmers with investment in improved roads	Good
Authority	C. S. Brinnemann, County Auditor

Wells County is in northeastern Indiana, with Bluffton as its county seat. It is for the most part a till plain, very level. Two moraines, the Salamonie and Wabash, cross the county, following quite closely the direction of the rivers. The maximum elevation of these ridges is not more than 45 feet, and the incision of the rivers is about 25 or 30 feet where greatest. The maximum relief in the county is therefore not more than 75 feet. The till is a yellow, compact clay, blackened in the low ground by organic deposits from the marshes that occurred in such places before ditching was extensively done. None of the numerous ditches get into gravel, the surface clay being some 16 feet thick on the average. In a number of rather widely separated spots it thins out to 4 to 8 feet, and here gravel pits have been opened. The moraines, too, are largely clay ridges. In places small local deposits

of gravel, from 500 to 2,000 yards, are found in the edges of the moraines.

The largest deposit of gravel that has been worked in Wells County is along Rock Creek southwest from Bluffton about seven miles in townships 25 and 26 north, range 11 east. At the Mendenhall pits, section 15, township 26, some 2,500 yards of excellent gravel have been removed by a steam scoop; and tests have shown that the gravel remaining here is practically unlimited in quantity. The pits have been worked to a depth of 25 feet, and the bottom of the gravel was not reached. A half-mile farther down the creek a pump in June, 1904, was at work throwing out 75 yards daily. This gravel is part of the great bed found in all this part of the State under the till. The erosion of Rock Creek has removed 10 to 15 feet of the clay over a valley probably one-half mile wide; and here, where the stripping is thin, the gravel can be easily gotten at.

The same bed of gravel is found at John Bell's, Section 3, Township 25 N. under 16 feet of till in his well. Here the gravel was 100 feet thick. Sections of a number of the oil wells in this vicinity show the same condition. About 400 yards from Bell's farm, in N. W. 1/4 of Section 9 the till thins out a little, and the gravel comes within 6 to 8 feet of the surface. A strong pit could be developed here, but a dredge pump would be necessary to remove the gravel because of the water which it bears.

At Ossian, in the northern part of the county, north of the Wabash moraine, gravel occurs in the valley of the little stream between the town and the railroad. It is excellent material and the stripping is not more than four feet. The beds are numerous, but rather small. Two pits near the bridge have yielded probably 2,500 yards of gravel each; while in the dredge ditch, which is nearly as deep as the pits and only 20 yards away, there is absolutely no sign of gravel. A half mile up the ditch from the bridge there is a large pit, from which 10,000 yards have been taken, with probably as much more left. These small pockets are numerous enough to supply the needs of this vicinity.

On the river road from Bluffton to Vera Cruz, about three miles from the former place, there are two pits from which gravel has been taken for the road. It is not very good material.

At the bridge over the Wabash near Vera Cruz there occurs considerable excellent gravel of fluvial origin. It is rather hard to remove because of water; but some 10,000 yards have come from this place and there is probably as much more left. The section shows:

Section at Wabash Bridge, near Vera Cruz.

		Feet.
1.	Soil	2
2.	Gravel	8+

The Arch Wall pit, one mile northwest from Bluffton, discloses a large bed of gravel in the river bottom. It is excellent material and easily gotten at. Tests show its presence in workable quantity for nearly 100 yards east and west and 20 to 25 yards north and south from the center of the present opening. The gravel appears to be a river deposit.

On the Eichhorn farm 7 miles northwest from Bluffton gravel pits have been opened in the overwash from the Wabash moraine and in low ridges outlying from it. The material is somewhat sandy but works fairly well.

At the bend of the Salamonie River on the line between Jackson and Chester townships a gravel pit has been worked in the overwash from the Salamonie moraine. It is small, and not profitable for development.

Scattered here and there over Wells County there are many small deposits, too small to be called "workable," which nevertheless supply the local necessities. The county surveyor tells me that all the county has gravel enough to build its roads except the southern tier of townships, and the western two of these can get their gravel from pits in the adjoining counties. Nottingham Township seems to be entirely without gravel, the only part of the county in that condition.

Macadam Stone in Wells County.

The central portion of Wells County is well supplied with a good limestone which outcrops in localities sufficiently close to cut down the expense of road building to a minimum. The stone is quarried at a number of places, but at only a few is it crushed for macadam. Probably the best equipped plant in the county

is that of the Shoemaker Brothers, two miles west of Bluffton. The quarry is at the head of a ravine where a little dome of Niagara limestone comes to the surface. The plant is of the usual type, except that jaw crushers are employed. The superintendent, Mr. Shoemaker, gives the following data:

Men employed	12
Capacity (daily in yards)	80

The stone here dips about 40° to the northwest, and the quarrying has revealed about forty feet of the strata. The rock appears to be of pretty much the same texture throughout, but its color varies from gray at the top to black at the bottom. It has been used only slightly for road work, but the road built of it stands wear excellently.

At Rockford the ditch along Rock Creek exposes a hard, sometimes cherty, limestone for a distance of more than two miles. The blasting for the ditch reveals some six feet of this rock along the whole exposure, and thousands of yards of rock, already pretty well broken, lie on the ditch banks ready for the crusher. The only use made of this valuable material is for road repairing, a little jaw crusher being operated here by the township. At least a thousand acres of ground in this vicinity are underlain by limestone usually not more than four feet down.

Just east from the Red Bridge, 400 yards from the courthouse in Bluffton there are limestone quarries whose product is used for building purposes in the vicinity. A little of this rock has been crushed for road material, but there is no attempt to operate a crushing plant regularly.

Samples of stone from the quarry of Shoemaker Bros., the Meyers quarry and from Rockford were sent to Washington for testing in the U. S. Road Laboratory, the results of the tests, together with the average of 192 samples of limestone tested at the same laboratory given as a standard of comparison being as follows:

Results of Physical Tests of Niagara Limestone from the Quarry of Shoemaker Bros., the Meyers Quarry and the Quarry near Rockford, Wells County.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight Per Cubic Foot, Pounds.	Water Absorbed Per Cubic Foot, Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
Average of 192 samples....................	2.7	165.7	1.39	5.7	8.7	3.4	11	32 59
Shoemaker Bros. Quarry....................	2.7	171.5	.50	5.8	6.9	13.5	8	14 29
Meyers Quarry....................	2.7	168.4	0.79	6.3	6.3	10.8	13	9 37
Quarry near Rockford, Wells County....	2.7	165.3	3.29	5.1	7.8	13	14	22 37

Quarry near Rockford. "Above the average in resistance to wear and cementing value, for dolomite. Best suited for light highway and country-road traffic."—Page.

Samples from the above quarries were analyzed by the chemist of the same laboratory, and the composition found to be as follows:

Analyses of Samples of Niagara Limestone from the Quarries of Shoemaker Bros., the Meyers Quarry and the Quarry near Rockford, Wells County.

	Shoemaker Bros.	*Meyers.*	*Rockford.*
Alumina (Al_2O_3)	1.3	1.75	1.39
Iron oxide (Fe_2O_3)	Trace	.75	1.51
Lime (CaO)	30.3	29.40	30.25
Magnesia (MgO)	18.87	20.16	16.97
Insoluble in hydrochloric acid..............	3.45	1.97	7.35
Loss on ignition............................	45.75	45.62	43.19
Totals	99.67	99.65	100.66

Other places at which limestone of excellent road building quality outcrops are given below:

1. Two miles southeast of Bluffton, the river and a little creek reveal a hard gray limestone.
2. At Murray, a similar rock is exposed in the river bed.
3. On the Haflich farm, two miles northwest from Bluffton, a limestone outcrops and has been burnt into lime.
4. On the east edge of the county, this Niagara limestone appears slightly, being better shown just across the county line.

At all four of these places crushing plants might be established and excellent road material obtained, but the cheapness of gravel renders that improbable for many years.

Summary.—Material abundant, sentiment good.

ADAMS COUNTY.

Area in square miles	335
Population in 1900	22,232
Miles of public roads	675
Miles of improved roads	216
Percentage of roads improved	32
Miles improved with gravel	102.5
Miles improved with crushed stone	113.5
Average original cost of gravel roads per mile	$2,000
Average original cost of stone roads per mile	$3,200
Total original cost of improved roads	$567,200
Annual cost of repairs per mile on gravel roads 5 years old	$70
Annual cost of repairs per mile on stone roads 5 years old	$25
Miles of improved roads (gravel) built in 1905	3
Miles of improved roads (stone) built in 1905	7
Miles of improved roads (gravel) contracted for 1906	4
First improved roads built	1889
Proportion of improved roads built since 1895	10%
Satisfaction of farmers with investment in improved roads	Good
Authority	C. D. Lewton, County Auditor

Adams County lies on the eastern border of the State, the fourth county from the northern boundary. Its county seat is Decatur. The topography is simple, being very plane, broken only by the valleys of the St. Mary and Wabash rivers and their tributaries. Two moraines, both low, follow the courses of the rivers. The drift is very thin as a rule, rock being found almost everywhere in the county at depths of 35 to 50 feet. The chief glacial deposit is till—yellow, stiff clay, extending to the rock as a rule. Occasionally thin beds of gravel occur just above the rock, but they are of no economic value, except as water reservoirs, unless the streams have removed the top layer of till.

There are not half a dozen "workable" gravel deposits in the county and probably will not be. Perhaps the largest deposit is the one in the edge of Decatur, northeast of the court house. The river here has removed most of the clay, leaving 8 to 12 feet of stripping. The material is quite sandy and not good for road use.

About 3½ miles from Berne there is a gravel pit on the farm of Chris. Hostettler. The gravel is little better than quicksand, but it is used on roads in the absence of better material.

Another deposit of gravel occurs about three miles north of Decatur, in the river bottom. It has been worked for roadstuff, but it is about exhausted.

The Irwin gravel pit four miles northeast of Preble is being worked at present. This deposit is along a little stream where some of the till has been removed. The gravel is mediocre, but is used for roadstuff.

There are no other gravel deposits in Adams County worth mentioning. The sentiment here is pretty strongly in favor of macadam, even where it must be imported. This is no doubt wise when the poor quality of gravel is considered.

Macadam Stone in Adams County.

The crushing plant at the J. S. Bowers quarry, about a mile north of the court house in Decatur, is a modern one. The usual types of machinery are here in use as follows: Gates' gyratory crusher, automatic screens, steam drills and derricks. Mr. Bowers, the owner, gives the following data:

Men employed	20
Capacity (yards per day)	80 to 100

He says further that roads may be built of rock from this quarry at a cost of $2,500 per mile. Trials of the rock for macadam have been uniformly successful, the material packing smooth and wearing well. The rock is hard to get at, being under 12 to 20 feet of till except in the river channel of which it forms the bottom. The section here shows:

Section at Bowers Quarry.

	Feet.
1. Soil	2—4
2. Yellow clay	6
3. Blue till	10
4. Limestone, hard, gray	12

Samples from the quarry were sent to the road testing laboratory at Washington, the results being as follows:

Results of Physical Tests of Stone from the Quarry of John S. Bowers, near Decatur, Adams County.

Specific gravity..........	2.7	Water absorbed per cu. ft..(lbs.)	1.11
Weight per cu. ft...(lbs.)	168	Cementing value—Dry...........	14
		Wet...........	40

"This sample consisted only of about six pounds of small pieces of rock. A fairly good cementing value."—Page.

About 300 yards south of Bowers's quarry the Fitzinger quarry gets into soft buff limestone that works well for building material and burns good lime. It is, however, too soft for road use and too expensive to get out.

At Pleasant Mills, Woods and Morris, contractors, have an excellent plant for the making of macadam. It is of the usual modern type. The rock here is quarried for the most part from the river bottom. It is a white limestone, the most handsome in the State aside from the best oölitic. It has very much the texture of marble and is pure white. According to the records of some of the roads built from this stone it can not be excelled. Roads down 8 years are in perfect repair today without any expense since they were built.

Samples of limestone from the plant of E. Woods & Company were sent to the U. S. Road Laboratory to be tested, with the following results:

*Results of Physical Tests of Niagara Limestone from Plant of E. Woods & Co., Pleasant Mills, Adams County.**

Specific gravity.................	2.56	French coefficient of wear.	3.91
Weight per cu. ft..........(lbs.)	159	Hardness†................	...
Water absorbed per cu. ft..(lbs.)	3.56	Toughness†...............	...
Per cent. of wear..............	10.23	Cementing value—Dry....	10
		Wet....	22

"Very low in resistance to wear, and low in cementing value. Would not use this material for roads if better is available."—Page.

A chemical analysis of the sample was made at the same laboratory, and its composition was found to be as follows:

*For standard of comparison see p. 79.

†No piece large enough for core was among the samples sent in.

Chemical Analysis of Niagara Limestone from Plant of E. Woods & Co., Pleasant Mills, Adams County.

	Per cent.
Alumina (Al_2O_3)	.25
Lime (CaO)	33.14
Magnesia (MgO)	19.63
Insoluble in hydrochloric acid	.32
Loss on ignition	46.79
Total	100.13

The Blue Creek quarry, 2½ miles south of Pleasant Mills, is a rather extensive affair. The plant is of the usual type, with a capacity of 200 yards per day, and employing 30 to 35 men. No figures as to price were available. The rock here is a thin-bedded, blue limestone, hard and well suited for road material.

JAY COUNTY.

Area in square miles	370
Population in 1900	26,818
Miles of public roads	800
Miles of improved roads	300
Percentage of roads improved	37.5
Miles improved with gravel	265
Miles improved with crushed stone	35
Average original cost of gravel roads per mile	$1,800
Average original cost of stone roads per mile	$2,700
Total original cost of improved roads	$571,500
Annual cost of repairs per mile on gravel roads 5 years old	$40
Annual cost of repairs per mile on stone roads 5 years old	$20
Miles of improved roads (gravel) built in 1905	20
Miles of improved roads (stone) built in 1905	10
First improved roads built	1875
Proportion of improved roads built since 1895	80%
Satisfaction of farmers with investment in improved roads	Good
Authority	L. H. Treheame, County Commissioner

Jay County is on the Ohio line, the fifth from the north boundary of the State. Half its surface is till plain, the rest being morainic, occupied by the gentle undulations of the Mississinewa moraine, and the inconspicuous swells of the Salamonic. The latter has at its southern side a few sharp knolls, and these are mainly sand or gravel. Aside from them, both moraines are clay, like the remainder of the county.

Some parts of this area are plentifully supplied with gravel, and other portions, as far as one can see in exactly similar situations are without it. The gravel is found in pockets in heavy till or else in the streams. The pocket gravel, usually pumped out, is good material. The stream deposits contain much dirt and are not nearly so good.

The sentiment for gravel roads in this county seems to have been replaced by a desire for stone. The latter product is handily obtained from Portland, Ridgeville and Decatur. There is probably no better road stone in the State than can be had at these places, and the railways can bring it within hauling distance of the greater part of the county. At Briant, where there is plenty of gravel for road building, the people nevertheless are building this summer (1905) three macadam roads.

In general, it may be said that every township in this county can build its roads without an excessive haul, except perhaps Wabash Township, in the northeast corner. In many places it will be advisable to haul farther, and get better material.

One of the best pits in the county, and one typical of this sort of territory is in sections 23 and 14, Greene Township. There is a local thinning of the till here, perhaps three miles west of Portland, and a very good gravel is extracted from a pocket between the till sheets. In section 31, Green Township, there is another pit like the former. Neither is very large, and the extraction of the gravel is a bit difficult, but the quality of the material more than repays the cost of getting it out, over that of obtaining creek gravel.

A good pit occurs 8 miles northwest from Portland on the Gardiner place. This is in a morainic knoll—the same famous Twin Hill gravel bank from which the C., B. and C. railway have obtained their ballast. The quantity is practically unlimited, the quality excellent. Some gravel has been shipped from here into Wells County, and one of the best gravel roads in the State is a two mile stretch about two miles south of Bluffton built from this material. It packs rapidly, giving a water-proof surface, and apparently has the quality of endurance.

There is an abandoned gravel pit about 10 miles east of Portland near the State Line. This also is in a morainic knoll, exposed by the stream. The gravel remaining is under a good deal

of stripping, but other pits might be opened in this vicinity. The gravel is good.

At Briant and at Westchester there are small pits of fair gravel. At the former place, the gravel is regarded as too dirty for road, and stone is being used. The latter pit is now being worked, and three or four miles of road being built.

At various places along streams and in knolls little pits running from 500 to 1,500 yards have been worked, and probably half the roads built from them. These small pits have been the salvation of many counties, as far as road materials go. Where the stripping is not too heavy, it is cheaper to work a number of little beds of gravel than to haul 4 or 5 miles from a larger one.

At the plant of the Portland Stone and Lime Company, two miles west of Portland, there is a bed of gravel just above the rock. This must be stripped before quarrying the stone; but the company sells the gravel and thus pays for the stripping. It is an excellent blue gravel, and would make good roads if there were enough of it. It is typical of the condition in most of this county. The rock is nearly always immediately overlain by 6-10 feet of gravel, and this by 14-60 feet of clay. Where erosion has removed part of the clay, the gravel may be gotten at, and furnishes a good road material.

Portland Lime and Stone Company.—This firm is just finishing an extensive plant, which will be as good as any when completed. They expect to be crushing by August 15. Much of their product goes into lime, but they get out crushed rock for concrete, macadam, etc.

Capacity (daily), yards	500
Men employed	40 to 50
Price (asked)	$0.65

The equipment is of the usual sort, Gates gyratory No. 6, and a No. 4 for tailings. This quarry is pretty deep, and if the plans carry out will some time be the deepest in the State. The rock seems to be getting better, the deeper it is followed, and the Superintendent expects to carry the work down 150 feet, if nothing prevents.

Samples of stone from the quarry of the Portland Lime and Stone Company were tested at the U. S. Road Laboratory, the tests resulting as follows:

*Results of Physical Tests of Niagara Limestone from Quarry of the Portland Lime and Stone Company, Portland, Indiana.**

Specific gravity	2.7	French coefficient of wear	5.7
Weight per cu. ft. (lbs.)	168.4	Hardness	4.5
Water absorbed per cu. ft. (lbs.)	.69	Toughness	8
Per cent. of wear	.7	Cementing value—Dry	19
		Wet	45

"Low in resistance to wear; fairly good cementing value. Best suited for country-road traffic."—Page.

An analysis of the sample was made at the same laboratory, with the following results:

Analysis of Niagara Limestone from Quarry of the Portland Lime and Stone Company, Portland, Indiana.

	Per cent.
Alumina (Al_2O_3)	.5
Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	31.3
Magnesia (MgO)	21.75
Insoluble in hydrochloric acid	.36
Loss on ignition	46.04
Total	99.95

Road sentiment is in a healthy condition in this county. The main roads and many of the side roads are graveled, and some of the principal highways are being macadamized.

BLACKFORD COUNTY.

Area in square miles	167
Population in 1900	17,213
Miles of public roads	360
Miles of improved roads	130
Percentage of roads improved	36.1
Miles improved with gravel	130
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,800
Total original cost of improved roads	$235,040
Annual cost of repairs per mile on gravel roads 5 years old	$100
Miles of improved roads (gravel) built in 1905	8
First improved roads built	1879
Proportion of improved roads built since 1895	27%
Satisfaction of farmers with investment in improved roads—	"Reasonably well satisfied."
Authority	Lewis C. Johnson, County Auditor

*For standard of comparison see p. 79.

This, the fourth smallest county of the State, with Hartford City for its capital, lies east of the north central portion of the State. A little more than half the county is till plain, and the southwestern corner is occupied by the Mississinewa moraine. This county has one of the most thoroughly graveled road systems of any county in the State. There is scarcely a house more than two miles from an improved highway, and 80 per cent. of the population live within one and a half miles. The roads are well built and well kept; the only disadvantage is the quality of the gravel, which is not first-class. Most of it is shaly, and soon grinds up under travel.

Practically all the road material that has been used in the county comes from four groups of pits. These are so situated that most roads have been built with less than a four-mile haul, except out at the ends of the roads. Here there are occasional stretches where the haul was 6 or 7 miles.

The best gravel pit in the county is the Dundee pit, 7 miles north of Hartford City. It is partly a river valley pit and partly from the bottom of the stream. It is pumped out and is of very fair quality. Some 30 to 35 miles of road have been built from here.

Another group of gravel-beds is the Edens-Clapper bunch, 5 miles southwest of Hartford City. These do not yield as much as the Dundee pit, and the product is not as good. It is dirtier and grinds up more quickly. However, some 20 miles of good road have been constructed out of this group of pits.

In the southeast part of the county the Wilcoxon-Whitecotton pits furnish most of the gravel. About 20 miles of road have been built of material obtained here, and there are 7 miles now being built. There will be several more roads built from here, in all probability.

A half mile from Montpelier there is a bank gravel pit which has furnished material for that part of the county. It is almost quicksand and makes a rather poor road.

There are altogether in this little county 130 miles of gravel road. One hears much in all parts of the county in favor of stone roads. With good macadam stone obtainable from Montpelier and Ridgeville, it will not be a difficult task to put crushed rock on the highways, and well-informed persons believe that

when the present gravel roads wear out they will be succeeded by macadam.

Baltes Stone Company.

This firm has its plant one mile east of Montpelier. The rock is an excellent hard limestone, with a quarry face of about 25 feet, and underlying probably 200 acres at a slight depth. The plant, while not the largest in the State, is very perfectly built and equipped. The machinery includes a Gates gyratory crusher No. 6, and a No. 4 for the tailings, a tramway for elevating rock and an automatic trip for emptying the cars, and the usual arrangement for screening the crushed product.

Capacity (yards)	500
Men employed	50
Price (asked)	$0.70

Samples of stone from the Baltes Stone Company's quarry were tested at the U. S. Road Laboratory, and results of the tests are herewith given:

*Results of Physical Tests of Niagara Limestone from the Quarry of the Baltes Stone Company, Montpelier, Ind.**

Specific gravity	2.7	French coefficient of wear	10.8
Weight per cu. ft. (lbs.)	165.3	Hardness	9.3
Water absorbed per cu. ft. (lbs.)	2.97	Toughness	...
Per cent. of wear	3.7	Cementing value—Dry	35
		Wet	52

"Fairly good cementing value and resistance to wear, for limestone. Well suited for highway traffic."—Page.

A sample of the stone was analyzed by the chemist of the same laboratory, with the results shown below:

Analysis of Niagara Limestone from the Quarry of the Baltes Stone Company, Montpelier, Ind.

	Per cent.
Alumina (Al_2O_3) and iron oxide (Fe_2O_3)	.85
Lime (CaO)	31.2
Magnesia (MgO)	16.56
Phosphoric acid (P_2O_5)	Trace
Insoluble in hydrochloric acid	9.56
Loss on ignition	42.16
Total	100.33

*For standard of comparison see p. 79.

At Keystone, in Wells County, not far from the Blackford line, a pump is this summer (1905) throwing out gravel. If necessary, much of the extreme north end of Blackford County could be graveled from there.

Blackford County as a whole is a till district, with the rock at various depths from 2 to 150 feet. In most places the material immediately overlying the rock is blue till 40 feet + thick. Over this comes 10-40 feet of yellow till. Between the blue and yellow sheets there are often small gravel sheets. These small gravel beds are often exposed by the erosion of the stream bluffs, and the gravel is carried down into the valley and deposited. It is from this source that most of the road material of the county is derived.

GRANT COUNTY.

Area in square miles	416
Population in 1900	54,693
Miles of public roads	900
Miles of improved roads	460
Percentage of roads improved	51.1
Miles improved with gravel	460
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$2,000
Total original cost of improved roads	$920,000
Annual cost of repairs per mile on gravel roads 5 years old	$70
Miles of improved road (gravel) built in 1905	40
Miles of improved road (gravel) contracted for 1906	3
First improved roads built	1866
Miles of improved roads built since 1895	250
Satisfaction of farmers with investment in improved roads	Good
Authority	B. A. Kinney

This county, with Marion as its county seat, is in north central Indiana, in the great till plain. It has two noticeable topographic features—the Mississinewa River and the moraine belt on the east side of the river. This belt is about 5 miles wide, has an elevation of 20 to 50 feet above the general plain, and extends across the county. Aside from the moraine and the streams, the surface of Grant County is very smooth, and till covered.

There is very little good gravel in this county. The river bends and terraces have been drawn upon for most of the gravel heretofore used, and the material is sandy and nearly everywhere dirty.

The presence of very much sand or dirt serves to make gravel unfit for roadstuff, and the roads in this county that have been built with the river gravel show for themselves. At various depths in the clay, rarely less than ten feet, there are pockets of gravel as good as any—grey water gravel, clean and excellent road material. Recently pumps have been put to work on these deposits and a much better quality of gravel is being thrown out.

The moraine in this county has a till surface with gravel and sand underneath. At the highest points of the ridge, this gravel stratum is 40 to 45 feet below the surface, but at or near the edges of the moraine, the till covering is often less than 5 feet. A typical bed of this sort is worked in Marion, some five blocks north of the court house. The section shows:

Section of Pit in Marion.

		Feet.
1.	Clay	3
2.	Coarse, bouldery gravel	3
3.	Finer gravel and sand	8

The upper gravel is not good road material, being too coarse to pack well. The lower, finer gravel would work well, if some care were exercised to keep out the boulders, and most of the clay. This has not always been done, and the roads have suffered.

About half way between Jonesboro and Marion, the traction company has a gravel pit in the base of a bluff. The section shows:

Section of Pit of Union Traction Company.

		Feet.
1.	Clay	4—10
2.	Coarse gravel	5—8

This gravel makes fair ballast, but is too coarse for ideal road material. By screening through coarse-meshed screens, good road stuff might be obtained.

There are several other pits like the two above described in the vicinity of Marion, all obtaining gravel from the beds under the till. Aside from the coarseness of much of the gravel, this material is good, and when screened will make a good road. The earlier roads in this vicinity were built of river-deposited gravel, because that was more easily obtained than the bedded material; and such river deposits contain little good road gravel.

At Keystone, in Wells County, not far from the Blackford line, a pump is this summer (1905) throwing out gravel. If necessary, much of the extreme north end of Blackford County could be graveled from there.

Blackford County as a whole is a till district, with the rock at various depths from 2 to 150 feet. In most places the material immediately overlying the rock is blue till 40 feet + thick. Over this comes 10-40 feet of yellow till. Between the blue and yellow sheets there are often small gravel sheets. These small gravel beds are often exposed by the erosion of the stream bluffs, and the gravel is carried down into the valley and deposited. It is from this source that most of the road material of the county is derived.

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Miles of public roads	900
Miles of improved roads	460
Percentage of roads improved	51.1
Miles improved with gravel	460
Miles improved with crushed stone	None
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Total original cost of improved roads	$920,000
Annual cost of repairs per mile on gravel roads 5 years old	$70
Miles of improved road (gravel) built in 1905	40
Miles of improved road (gravel) contracted for 1906	3
First improved roads built	1866
Miles of improved roads built since 1895	250
Satisfaction of farmers with investment in improved roads	Good
Authority	B. A. Kinney

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The upper gravel is not good road material, being too coarse to pack well. The lower, finer gravel would work well, if some care were exercised to keep out the boulders, and most of the clay. This has not always been done, and the roads have suffered.

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Section of Pit of Union Traction Company.

	Feet.
1. Clay	4—10
2. Coarse gravel	5—8

This gravel makes fair ballast, but is too coarse for ideal road material. By screening through coarse-meshed screens, good road stuff might be obtained.

There are several other pits like the two above described in the vicinity of Marion, all obtaining gravel from the beds under the till. Aside from the coarseness of much of the gravel, this material is good, and when screened will make a good road. The earlier roads in this vicinity were built of river-deposited gravel, because that was more easily obtained than the bedded material; and such river deposits contain little good road gravel.

Six miles east of Marion some of the till has been eroded by the headwaters of Lugat's Creek, and there seems to have been a thin till covering to begin with. Here a pump was at work in the summer of 1905 throwing out an excellent grey water gravel which was being used on the roads. It worked very well.

In the vicinity of Fairmount the clay is very heavy. Very few wells find gravel short of 20 feet, and many go 45 feet. The gravel that has been used in this vicinity is creek gravel obtained from the bends of a little stream about a mile west from the town. It is pretty dirty, and is hardly to be classed as good. The supply in this area is not nearly adequate, and probably never will be, since the surface clay is too deep to allow the gravel to be worked.

Near Swayzee there is no gravel anywhere in sight. Even sand is not to be had here, all that used for building purposes being shipped in. The nearest gravel is on Pipe Creek, four miles away. A gravelly till, with not more than 20 per cent. gravel, is sometimes used here for road material, and seems to answer pretty well.

Converse and Vicinity.

This village is on the line between Howard and Grant counties, in the midst of a clay district. Pipe Creek and Little Pipe Creek both cut through the clay, and get very close to the top of the underlying gravel. On Little Pipe Creek, just in the edge of Converse, there is a body of gravel a half mile long and 50 to 150 yards wide. A number of test-holes showed:

	Feet.
1. Soil and clay	2—3
2. Gravel	4—6+

This gravel is a fine grey material, as good as can be found anywhere. There is practically no limit to the amount obtainable, since the depth of the gravel is probably 20 feet, judging from well sections. This is a very favorable place for locating a gravel and sand pit; either a gravel pump or a scoop or dredge will have to be used in getting out the gravel, however, since water is carried in great quantities.

Big Pipe Creek, 1½ miles east, also gets pretty well down into the clay, but it is still 5 to 6 feet down to the gravel.

Van Buren and Northeast Grant County.

This area is one of low black ground with clay knolls rising out of the swales. There is no gravel at the surface, and not very much anywhere else. Under the black soil there is usually 4 to 15 feet of clay, but occasionally a small gravel bed is found between the black ground and the clay. In such places a pump can easily get the gravel, since it is heavily water-bearing. The material obtained is pretty fine grained, as a rule, but it has a good packing quality and makes a good road. Two such beds have been pumped this summer, one on the Trevison farm, two miles east, and another two miles south of Van Buren.

Part of northern Grant County might be graveled from the pits along the tributaries to the Salamonie in Huntington County.

Near Fox's Station, a large gravel pit has been operated by the traction company. It is on the north side of the moraine, and is pretty much like the moraine gravels on the southern side. It seems, however, to have fewer large boulders in it.

At Upland and vicinity the gravel used comes from the Mississinewa and from Walnut Creek, two miles north. It comes partly from the bars and partly from the deposits in the bends of the stream. It is quite dirty, but is better than no gravel at all.

Macadam Stone in Grant County.

Marion Stone Company.—The plant of this company is about a mile north of the court house. The rock is taken from a quarry near the river, under 2 to 3 feet of stripping. The section shows:

Section of Quarry of Marion Stone Company

		Feet.
1.	Soil	2—3
2.	Yellow, soft stone	4
3.	Heavy blue stone	8

This stone seems very soft, and with too little lime in it for good macadam. It is said, however, to work pretty well on the road. The plant just now is very much run down. The company intends making extensive repairs and alterations. Their present capacity is some 300 yards per day, with 20 to 25 men employed. The price obtained varies from time to time, 60 cents being a fair average.

Samples of limestone from the quarry of the Marion Stone Company were sent to the U. S. Road Laboratory for testing, and the following results were obtained:

*Results of Physical Tests of Niagara Limestone from Quarry of the Marion Stone Company, Marion, Grant County, Ind.**

Specific gravity	2.6	French coefficient of wear	7.8
Weight per cu. ft. (lbs.)	159	Hardness	2.5
Water absorbed per cu. ft. (lbs.)	4.72	Toughness	15
Per cent. of wear	5.2	Cementing value—Dry	44
		Wet	56

"Best suited for highway and country-road traffic."—Page.

Analysis of the sample was made at the same laboratory, and the composition was found to be as follows:

Analysis of Niagara Limestone from Quarry of the Marion Stone Company, Marion, Grant County, Ind.

	Per cent
Alumina (Al_2O_3)	2.12
Iron oxide (Fe_2O_3)	1.77
Lime (CaO)	19.50
Magnesia (MgO)	7.95
Phosphoric acid (P_2O_5)	.31
Insoluble in hydrochloric acid	41.83
Loss on ignition	26.28
Total	99.76

Another quarry with precisely the same rock is located 5 miles west of Marion and 1½ miles northwest of Roseburg, on the Willcutt farm. A little crusher is working here, and several miles of road are being built.

Road sentiment is good in Grant County, most of the main roads, and many of the side roads, being improved. A good deal of gravel has been used which ought not to have been, but in the future more care will be exercised in selecting material. The river material should be avoided, and the bed gravel down under the clay used, even if it is more expensive.

*For standard of comparison see p. 79.

HOWARD COUNTY.

Area in square miles	295
Population in 1900	28,575
Miles of public roads	600
Miles of improved roads	263
Percentage of roads improved	43.8
Miles improved with gravel	263
Miles improved with crushed stone*	None
Average original cost of gravel roads per mile	$2,400
Total original cost of improved roads	$631,200
Annual cost of repairs per mile on gravel roads 5 years old**	$25
Miles of improved roads (gravel) built in 1905	13
Miles of improved roads (gravel) contracted for 1906	4.5
First improved roads built	1870
Miles of improved roads built since 1895	115
Satisfaction of farmers with investment in improved roads	Good
Authority	W. L. Benson, County Auditor

*The improved roads in part are repaired with crushed stone.

**Average annual cost of repairs per mile on gravel roads over five years old is given at $60.

Howard County is in the north central part of the State, with Kokomo as its county seat. It is an almost featureless county, being a flat plain, with very few knolls rising twenty feet or more above the surface, and only one stream, Wild Cat Creek, getting that far below. It is a clay county, at least 90 per cent. of the surface being a yellow clay. There is no sign of surface gravel or sand anywhere, and no wells which get into sand or gravel short of 10 feet. Just beneath the yellow clay there is a blue till which runs down to the underlying limestone, where the depth of the latter is not more than 50 feet. Where the drift is much thicker than that, there seems to be a large gravel bed in which the better wells of the county find their water.

There are very few surface pits in this county, since the till is usually at least 10 feet thick. In such an area, the only workable gravel is along the streams where erosion has removed the overlying till. Wild Cat Creek, which runs east and west almost the length of Howard County, has a valley 15 to 20 feet deep and in a number of places gets down to the gravel. At least half the gravel used in the county has come from this stream and its tributaries. As a rule, this material is dirty and poor for road purposes.

The northern tier of townships is practically without road material. However most of this section is within hauling distance of Deer Creek, in Cass County, and has drawn largely upon that source for its road material. Away up in the northwestern corner of the county there are several small pits where there is a local thinning of the till. No one of these has an apparent capacity of more than a thousand yards.

The best pit on Wild Cat is about 9 miles southwest from Kokomo, in Sec. 1 (2 E., 23 N.). The section shows:

Section of Pit on Wild Cat Creek.

		Feet.
1.	Yellow till	6—10
2.	Gravel and sand	8—12
3.	Blue till	2+

This pit would be classed as small, its content probably not being more than 6,000 or 8,000 yards. The quality of the gravel is not good, there being so much sand in it that it soon grinds to dust on the roads.

Russiaville and Vicinity.

Russiaville is ten miles southwest of Kokomo on the Clover Leaf Railway. It is not far from Honey Creek, a tributary of Wild Cat, which gets down 20 to 25 feet into the till and consequently reveals the gravel. At London, two miles north of Russiaville, there is a good pit in a deep ravine. The section shows:

Section of Pit at London.

		Feet.
1.	Yellow till	3
2.	Blue till	2—5
3.	Gravel and sand	12 to 15

The face of the gravel bank here is 50 feet long and 15 feet high. There are in sight about 20,000 yards of excellent grey water gravel, which would make good road material if carefully quarried. In practice, however, sand and dirt have been allowed to enter in such quantities that the roads built from this pit are very dusty and are being rapidly ground to powder.

On Thomas Richardson's farm, one-half mile southwest of the above, is another pit of about the same size, containing good gravel with very little sand. Another similar pit, with slightly more sand, occurs 1½ miles southeast of Russiaville. This corner of the county is well supplied with the best gravel in the county.

Half a mile southwest of Greentown the interurban railway has a gravel pit in the creek bed. A steam scoop has here been at work dragging out a conglomeration of clay, sand, gravel and boulders. It is dirty stuff, totally unfit for road material. Two miles southwest of Greentown, and at Jerome, 4 miles south, there are also pits of sand and gravel. This material is too sandy to be of much value, and ought not to be used, since the expense of maintaining a good road will in a few years build a stone road.

Macadam Stone in Howard County.

Chaffin Brothers Stone Company.—The quarry belonging to this firm is 1½ miles southwest of Kokomo in the valley of Wild Cat Creek. The stone is exposed here over an area of possibly 160 acres, from 2 to 8 feet below the surface. For the most part there is little dip, although there are some crumplings of the strata. The rock is a laminated water limestone much resembling shale, and running into shale in some places. When freshly quarried it is rather soft, but hardens upon exposure. It appears to be pretty soft for macadam, but some roads built from it stand up fairly well after three or four years' service. It is at all events better than the sandy gravel found in the county.

The plant is of the usual type, including a Gates gyratory crusher, No. 4, screens, elevator, bins, etc.

Capacity (yards)	200
Men employed	25

The price obtained varies. An average of 65 cents per yard is fair for all stone sold.

Samples of stone from Chaffin & Co.'s quarry were tested at Washington, in the U. S. Road Laboratory, with the following results:

*Results of Physical Tests of Water-Limestone from the Quarry of Chaffin & Co., Kokomo, Howard County, Ind.**

Specific gravity	2.44	French coefficient of wear	9.69
Weight per cu. ft. (lbs.)	152.8	Hardness	5.3
Water absorbed per cu. ft. (lbs.)	6.50	Toughness	17
Per cent. of wear	4.13	Cementing value—Dry	28
		Wet	42

"Slightly above the average in resistance to wear for limestone, with fair cementing value. Should give good results under highway and country-road traffic."—Page.

A chemical analysis was made of the stone at the same laboratory, and the following composition was shown:

Analysis of Water-Limestone from the Quarry of Chaffin & Co., Kokomo, Howard County, Ind.

	Per cent.
Alumina (Al_2O_3)	1.00
Lime (CaO)	34.15
Magnesia (MgO)	13.21
Insoluble in hydrochloric acid	10.03
Loss on ignition	41.54
Total	99.93

South and west from Kokomo there are three or four other firms engaged in the stone crushing business. Leach and Company, Wilson, Interurban, and Deffenbaugh, all have plants of about the same style and capacity, running perhaps 100 to 150 yards per day when at work. They were all slack in the summer of 1905, their output being mainly for concrete work. There is no demand for their product upon the roads, away from local demands. This rock can not compete with the harder limestones of northern Indiana for macadam purposes.

Samples of stone from the property of J. M. Leach & Co. were tested at the Road Laboratory at Washington, D. C., with the following results:

*For standard of comparison see p. 79.

*Results of Physical Tests of Water-Limestone from the Land of J. M. Leach & Co., Kokomo, Howard County.**

Specific gravity	2.45	French coefficient of wear	9.6
Weight per cu. ft. (lbs.)	153	Hardness	0
Water absorbed per cu. ft. (lbs.)	6.21	Toughness	8
Per cent. of wear	4.2	Cementing value—Dry	46
		Wet	63

"A very soft but fairly tough rock with a rather good resistance to wear, and a good cementing value. Suitable to light traffic roads or as a binder."—Page.

Road sentiment was slumbering in Howard County in 1905. The energies of the people were being expended upon bridges, the main roads having been pretty well worked over in 1904 and the year before. It will be some time before the road question is again agitated, and macadam will in all likelihood be the material demanded.

CARROLL COUNTY.

Area in square miles	370
Population in 1900	19,953
Miles of public roads	847
Miles of improved roads	230
Percentage of roads improved	28.3
Miles improved with gravel	215
Miles improved with crushed stone	15
Average original cost of gravel roads per mile	$1,600
Average original cost of stone roads per mile	$2,400
Total original cost of improved roads	$380,000
Annual cost of repairs per mile on gravel roads 5 years old	$34.80
Miles of improved roads (gravel built in 1905	28
Miles of improved roads (stone) built in 1905	15
Miles of improved roads (gravel) contracted for 1906	12
Miles of improved roads (stone) contracted for 1906	10
First improved roads built	1881
Proportion of improved roads built since 1895	60%
Satisfaction of farmers with investment in improved roads	Good
Authority	Fred. H. Engel, County Auditor

This county, with Delphi as its county seat, is the third east from the Illinois line, and the fifth south from the Michigan line. Its surface for the most part is smooth or undulating, there being few elevations except a few morainic knolls on the west side, near

*For standard of comparison see p. 79.

the Wabash, and a wedge of high ground between that river and the Tippecanoe. The only topographic feature of striking noticeability is the great valley of the Wabash, a mile wide and 100 to 125 feet deep. Wild Cat and Deer creeks have shallow valleys except for a few miles back from their mouths.

The general expression of the county is till. The surface of the plain is practically all clay, with gravel pockets varying from 500 to 5,000 yards included within it. These pockets are sometimes near the surface, but usually 15 to 25 feet down. The Wabash terraces, two or three in number, make their appearance here, and as a rule are all gravel. Where the underlying rock is not more than 10 or 15 feet down, gravel may be obtained without excessive stripping, since a 4 to 10-foot gravel bed is usually found just above the rock. The Wabash and Tippecanoe River terraces furnish plenty of good gravel for all roads in hauling distance, and Wild Cat and Deer creeks are the salvation of the rest of the county as far as gravel goes.

Delphi and Vicinity.

A mile north of Delphi, in the river bluff there is a large gravel and sand pit, in which there is some good road material, if care is used to keep out the sand. A section of the bluff shows:

Section of Pit North of Delphi.

	Feet.
1. Till or yellow clay	8
2. Gravel, compact and fine-grained, also sand	25 to 30
3. Yellow and blue till	60

In this pit the sand is probably more abundant than the gravel. There ought to be good road material here, as the gravel in the bank is so firmly cemented that strong hammer blows are required to crush it. The hill road here has been built of this material and is an excellent piece of road. In a number of places in this region a gravel road-bed is covered with limestone screenings, giving a smooth asphalt-like finish. From this hill top, a number of gravel streaks are in sight, in which pits could be opened. There is some difficulty in working them, however, since they are 50 to 60 feet above the river, and the bluff is usually steep.

The terraces of the Wabash near Delphi contain gravel, but as a rule it is dirty. Of course, it is better than no gravel at all, but this terrace gravel should not be used if bed gravel can be obtained. Southeast of Delphi there are a number of small pits in the bluffs of Deer Creek and its tributaries. One such is on the Bradshaw farm, and another on Wise's place. These pits as a rule run from 500 to 1,500 yards, of rather poor gravel.

The Tippecanoe River has cut down 60 to 80 feet into the till and reveals numerous gravel beds, which are small and hard to get at. The numerous bends of the stream contain gravel and sand deposits which might be used for road purposes. It is poor material, however, and ought not to be used unless nothing else can be afforded.

Deer Creek and Wild Cat Creek, with their valleys 20-25 feet deep, get down far enough into the till to reveal gravel beds in some places. A good deal of road has been built from these pockets, and it is none of it good. The expense of getting it out, hauling 5 or 6 miles and frequently repairing will build a stone road in most places, and the sentiment for stone road is making much progress in this county.

Northeastern Portion of the County.

In Washington Township, in the northeast corner of the county, Rock Creek exposes for a distance of three miles, a fair quality of limestone which can be easily worked. There are four or five different varieties of rock, but they are all fairly hard, and all limestone. The township is expecting to buy a stone crusher this autumn (1905) and build three or more miles of road each year until the township demands are supplied. Gravel can not be obtained here without excessive hauling, and it is not good. This township is so far off the railroad that it could not afford to haul crushed rock from a switch, and the plan now being considered seems to be the best under the circumstances.

The gravel proposition, as a whole, in Carroll County, is a bad one. There is some good gravel along all the streams, but in most places it is badly mixed with sand, and has a heavy stripping. Probably all the townships except Washington and Madison have enough material to improve their main roads. In practice, how-

ever, the roads are not very well built. In the vicinity of Delphi, the roads are excellent, and in other parts of the county one meets occasionally good stretches. The great faults of road making are, however, apparent over most of this county—poor selection of material, poor grading, and inspection that had not enough technical knowledge.

Limestone for Road Purposes.

Delphi is favorably situated for limestone roads. There are two crushing plants located near the city, some 400 yards apart. One, that of the Delphi Stone Co., does a general crushed rock business, selling its product both at home and abroad. Pierce's crushing plant is at present engaged in getting out crushed rock for some twelve miles of macadam road which its owner is building. Since the gravel of this region is either bad or hard to get at, it may be not much more expensive in the end to build stone roads. This stone builds a very good road, as shown in many places in the vicinity; and there seems to be a growing tendency to use crushed rock in place of the gravel.

Delphi Crushed Stone Company.—This company, a Chicago concern, has a large, well equipped plant, representing an investment of about $35,000. Their quarry is in the river valley, where the stripping runs from 2 to 4 feet. The rock is elevated and carried to the crusher by means of an overhead cable-way. The crusher is a Gates gyratory, No. 6, and a smaller one for the tailings—a No. 4. Shipping facilities are good.

Men employed	40 to 50
Capacity (yards)	400 to 500
Price (per yard) not less than	$0.50

At Pierce's crusher, the product is used by the owner in fulfilling his own road contracts. The rock is about the same as that of the other plant, except that this is nearer the surface and somewhat more weathered. This plant employs 25 to 30 men, and has a capacity of 150 to 200 yards per day.

Samples of stone from the Delphi Stone Company and from the Fred Showalter quarry in Washington Township, were tested in the U. S. Road Laboratory at Washington, D. C. The results of the tests are herewith given, together with the average of 192

limestones tested at the same laboratory, as a standard of comparison:

Results of Physical Tests of Niagara Limestone from Quarry of the Delphi Stone Company, and from Quarry in Washington Township, Carroll County.

ORIGIN OF SAMPLE.	Specific Gravity.	Weight Per Cubic Foot, Pounds.	Water Absorbed Per Cubic Foot. Pounds.	Per Cent. of Wear.	French Coefficient of Wear.	Hardness.	Toughness.	Cementing Value. Dry—Wet.
Average of 192 samples	2.7	165.7	1.39	5.7	8.7	3.4	11	32 59
Delphi Stone Co.	2.77	171.52	.75	5.09	7.86	10	14	14 42
Washington Township, Carroll County	2.73	171.5	.50	8.73	4.58	12	21	7 45

Delphi Stone Co. "A fairly hard and tough limestone, with a fair cementing value."—Page.

This rock, in practice, has been found to make excellent roads, durable and free from dust.—Ward.

Washington township stone. "Low in resistance to wear, only fair cementing value. Should not be used if better material is available."—Page.

A chemical analysis of the two samples was made at the same laboratory, and the results showed as follows:

Chemical Analysis of Niagara Limestone from Quarry of Delphi Stone Company and from Quarry in Washington Township, Carroll County.

	Delphi Stone Co. Per cent.	Washington Twp. Per cent.
Lime (CaO)	....	50.7
Calcium carbonate (CaCO)	53.36	....
Iron oxide (FeO)	1.06	.55
Magnesium carbonate (MgCO)	44.6	....
Alumina (AlO)	.64	....
Silica (SiO)	.40	....
Phosphoric acid (PO)	.016	....
Insoluble in hydrochloric acid	....	1.31
Loss on ignition	....	43.38
Total	100.076	95.94

The road sentiment is in a healthful condition in Carroll County. There are some 150 miles of improved road in the

county, with 80 miles being built this year. The people of the county are justly proud of their land, both its beauty and fertility; and they are rapidly improving their means of transportation. More sentiment for stone roads was found here than in any other county except Adams, and it seems probable that for most of its area Carroll will, in a few years, have a road system equal to that of any county in the State.

Acknowledgments.

In performing the field work embodied in the foregoing report, the writer gratefully acknowledges the valuable assistance of Mr. John Rockhold, Recorder of Benton County; of Mr. William Hogg, superintendent of the Hely stone plant at Monon; of Mr. Kent, of Brookston; Messrs. Hassatt and Sammons, of Kentland; of William Ambler, of Winamac; of Dr. Gould, the veteran naturalist of Rochester; of Dan North, Surveyor of Wells County; of James Bennett, of Bluffton; of Mr. Kelley, Surveyor of Miami County; of Mr. Frank Bridges, of Wabash; and of many farmers and road contractors who gave him the benefit of their local knowledge and experience.

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Section VII.

THE ROADS AND ROAD MATERIALS OF ALLEN COUNTY.

TOGETHER WITH SUCH OTHER INFORMATION AS IS OF PROBABLE GENERAL INTEREST.

By J. A. Price.

Area in square miles	660
Population in 1900	77,270
Miles of public roads	900
Miles of improved roads	450
Percentage of roads improved	50
Miles improved with gravel	450
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,000
Total original cost of improved roads	$450,000
Annual cost of repairs per mile on gravel roads 5 years old	$100
First improved roads built	1887
Miles of improved roads (gravel) built in 1905	25

Satisfaction of farmers with investment in improved roads—
"Fair, but wish more permanent roads with better drainage and grades."
Authority........................M. A. Ferguson, Ex. Co. Commissioner

Allen, the largest county of Indiana, is located in the northeastern part of the State, and is bounded on the north by Dekalb and Noble counties, on the west by Whitley and Huntington counties, on the south by Wells and Adams counties, and on the east by the Ohio State line.

General Topography.—In general the topography of the county is quite diversified, running from low, level plains to rolling and hummocky ridges. The highest points in the ridges rise more or less gently from above the creek and river valleys. A very close relation exists between the topography and geology of the county. In fact, the present relief of the county is due to present geological conditions, the action of glaciers and interglacial streams and the work of postglacial waters.

General Geology.—Allen County lies in that portion of the State that was covered during glacial times by the Erie ice-lobe.

During interglacial times a portion of the large ice sheet that then covered the land to the northeast, moved in a southwesterly direction, crossing the northeastern part of the State and extending to the southwest, to near where the city of Wabash is now located. Reaching this point, there was a halt in the forward movement of the ice sheet, due to one or two causes, or to the combined action of these two causes, namely, the rapidity of the onward movement of the ice sheet may have decreased, or the forward motion may have remained the same, while the melting at the end of the ice-lobe increased. Either of these causes might have produced this halt in the forward movement of the ice-front, or there may have been a combination of these two causes, which would have produced a similar result. The present condition indicates conclusively that the end of the ice sheet remained practically stationary at this point. As the body of the ice moved forward to be melted at its extremity, a large amount of detritus was deposited around the edge of the ice lobe. By this process of accumulation a large terminal moraine was formed. The semi-circular condition of this moraine indicates that the Erie ice-lobe had also the same general shape. Following this period of equalization between the onward movement and the melting process, there came a time when the melting was greater than the forward movement. This produced a recession of the ice front.

Later this backward movement of the ice front ceased, as is indicated by the existence of a second terminal moraine, which is located near where the city of Huntington now stands. Following this period of rest, the ice front again receded and then halted, forming another terminal moraine. This moraine is also, as are the previous ones, more or less semi-circular in shape, and lies just west of the city of Fort Wayne. The ice front again receded and made another halt, building a fourth terminal moraine.*

After the formation of the last of these terminal moraines the ice front again receded, probably without interruption until it was withdrawn to the northeast past the present site of Lake Erie. But, owing to the fact that the land in front of the ice sheet sloped toward the ice, a large body of water gathered around the end of the ice lobe, forming a large interglacial lake, known as the

*For a fuller report on the formation of this series of moraines see the 17th and 18th reports of this Department.

Maumee Lake. As the ice front receded this body of water gradually grew larger, until it covered several hundred square miles; but finally when the ice front had withdrawn to the northeast the waters of this lake were drawn away, leaving a large, level, swampy and fertile lake bottom. A portion of this plain is included in the eastern part of Allen County, forming a triangular tract of land with the apex at New Haven. The Maysville wagon road bounds this tract of land on the north and the Van Wert wagon road on the south. A glance at the accompanying map will locate this lake bottom, designated as the Maumee Lake bottom. Thus it is that the principal physical features of Allen County owe their existence largely to the action of glaciers and interglacial waters. The three principal physical features of the county are terminal moraines, morainic plains and lake bottoms.

Interglacial Drainage.—During interglacial times the drainage was to the southwest into the Wabash River. After the Erie ice lobe had receded to the northeast, forming Maumee Lake, the outlet to this lake was also to the southwest into the Wabash. Evidently the river flowing from Maumee Lake was a very large one. This is further indicated by the existence of a large river valley extending from a point east of the city of Fort Wayne to the southwest, joining the present Wabash River valley near Huntington. This channel, or river valley, is known as the Erie-Wabash gap. After the recession of the ice lobe the waters of Maumee Lake were drawn away and the St. Joseph's and St. Mary's rivers united, forming the Maumee River, a more or less sluggish, meandering stream which flows to the northeast across the Maumee Lake bottom and empties into Lake Erie.

Postglacial Drainage.—At present the eastern and central parts of the county are drained by the St. Joseph's, St. Mary's and Maumee rivers, together with their tributaries, while the western part of the county is drained by Eel River, Aboit and Little Prairie creeks and their tributaries.

During interglacial times these streams were much larger than they now are, and in general flowed at a higher level, ranging from 10 to 30 feet above their present channel. This fact, as we shall later see, had considerable to do with the deposition, location and distribution of the sand and gravel deposits.

As previously stated, the topography of the county is diversified, ranging from low, level tracts to irregularly rolling ridges. The surface of the moraines is more or less broken, presenting in general a rolling and hummocky surface. The intermorainic plains are not so broken. In general they present a gently rolling surface, with here and there a broken and somewhat irregular slope. The moraines vary in width from a few hundred yards to eight or ten miles or more.

Sand and Gravel Deposits.

The sand and gravel deposits of Allen County naturally fall under four heads, namely, (a) the deposits left by the high waters of the interglacial streams; (b) the wash gravel, which is found in the channels of the present streams; (c) kames, and (d) lake beach deposits.

Distribution.—The deposits resulting from the high waters of interglacial streams are found distributed in a general way along the present stream valleys. This is especially true of the St. Joseph River, where a large number of such deposits lie just north of Fort Wayne and along the east bank of the stream. Farther to the north along this stream the deposits are not so abundant and lie in detached masses. The largest of these deposits is found in and about Cedarville. As will be seen further on, but a very small portion of this deposit is suitable for road material, as it consists principally of sand. A few detached deposits belonging to this class are found along the valley of the St. Mary's River, Aboit Creek, Erie-Wabash gap and the interglacial valley of Cedar Creek.

The present channels of the Maumee and St. Joseph rivers contain no small amount of *wash gravel.* However, but little of this gravel has been utilized for road purposes. A number of deposits composed of excellent gravel for road purposes are found in the channel of the Maumee River between Fort Wayne and New Haven. Some little of this gravel has been removed and utilized for road purposes, making an excellent road. Farther to the northeast, through Milan and Maumee townships, there are a number of gravel deposits in the channel of the Maumee River. The public roads through these townships, especially Maumee

Township, could be very much improved by making use of the gravel found in these deposits.*

A number of deposits are included in what we have designated as *kames*. However, the question arises as to whether we are correct in our classification of these deposits. It certainly is true that some of these deposits owe their existence to one or more agents. This is especially true of those found in sections 19, 20, 21, 28, 29 and 30 (30 N., 12 E.), and in sections 25 and 26 (30 N., 11 E.). These deposits may have been formed by the interglacial St. Mary's River, which left its present channel in section 21 (30 N., 12 E.) and flowed to the southwest through sections 28, 29 and 30 (30 N., 12 E.) and sections 35 and 36 (30 N., 11 E.), emptying into the interglacial Wabash River. It then shifted its channel farther to the north, and between these two interglacial channels there lies a broken ridge of sand and gravel deposits. Another shift to the north was made by the St. Mary's River, and there deposits were formed. These may have been formed wholly or in part by this interglacial stream or they may have been formed by subglacial streams. Hence the question with reference to the accuracy of this classification. However, in sections 9, 10, 11, 13 and 14 (30 N., 14 E.) there occur two deposits which seem to belong unquestionably to kames. The same is true of deposits found in sections 10 and 15 (29 N., 15 E.).

The lake beach deposits lie distributed along the shore lines of the interglacial Maumee Lake. A glance at the accompanying map will reveal the fact that these deposits on the north extend from a point in the northeastern part of the city of Fort Wayne to the east for a distance of four miles, and then run to the northeast and follow the Maysville wagon road to the county line. The deposits are not continuous, but lie here and there along the lake beach. Probably the heaviest deposits lie in sections 25 and 26 (31 N., 13 E.). A number of openings have been made in this deposit and no small amount of the gravel has been removed. To the south the deposits are not so numerous and the ridge marking the boundary of the lake is broken in several places. The heaviest deposit is found just southwest of New Haven. Considerable gravel has been removed from this deposit, and in a general way

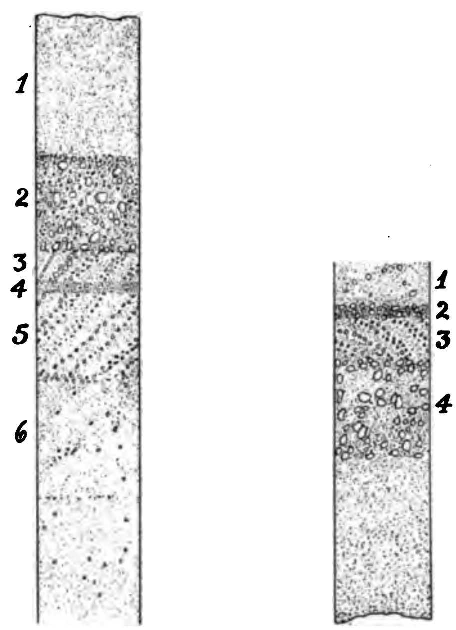
*For a more definite location of these deposits see a subsequent page, where a detailed discussion of the various sand and gravel deposits is given.

makes a very good road. Farther to the southeast, in Jefferson and Jackson townships, but very little gravel is found. This is partly accounted for from the fact that a number of streams break through the ridge and may have removed the deposits in case they were left there by the waters of Maumee Lake.

Township 30 North, Range 12 East.

This township contains probably more gravel and sand than any other township in the county. The city of Fort Wayne is located in its northeastern part, and the larger part of the gravel used for street and building purposes in the city is taken from these deposits. Two large gravel pits, the Curdes and Brown pits, occur near the western limits of the city. Probably the greater portion of this deposit has been removed.

Sections *1* and *2* show the character of outcropping strata at the Curdes pit. On the whole, the exposed strata as shown in section



Sec. 1. Sec. 2.

Figs. 26 and 27. Sections of the exposed strata at the Curdes Gravel Pit, on the west side of the city of Fort Wayne.

2 are coarser than those shown in section 1. In each section the top stratum is the same, being composed of fine, whitish sand

varying in thickness from three to six feet. Farther back on the hill this stratum increases in thickness, reaching a maximum of 14 feet. Throughout, the sand forming this stratum is very fine and apparently wind blown material. Stratum number 2 in each section consists of sand and gravel, its composition varying at different places. In this stratum there is a general change in the character of the deposits running from the top to the bottom. At the top it consists of a mixture of sand and gravel, with scattered pebbles, and runs to a coarse gravel at the bottom. Stratum number 3 in section 1 runs to a wedge shape, and in coming west toward section 2 disappears long before reaching the point where section 2 was made. Stratum number 4 is composed of fine and light colored sand. This stratum is only exposed for a distance of about 12 yards, running gradually to a point at each end. Stratum number 5 in section 1 corresponds to stratum number 3 in section 2. Stratum number 6 in section 1 corresponds to stratum number 4 in section 2, and has thinned down to a thickness of about six inches. Stratum number 7 in section 1 is composed of sand and fine gravel, with an occasional pebble. A few feet to the left of where section 1 was made this stratum ends abruptly, and in its place at about the same height in section 2 occurs an irregularly cross-bedded stratum of sand and gravel. The dip of the cross beds is about 45 degrees. Following this stratum farther to the left it gradually runs into an irregular bed of sand and fine gravel. The material forming stratum 7 in section 1 makes an excellent sand for artificial stone. The following section was obtained near the east end of this pit:

Section near East End of Curdes Gravel Pit.

	Feet.	Inches.
1. Sand and soil	4	..
2. Sand and gravel	4	..
3. Fine sand	2	..
4. Sand with small amount of gravel	20	..
5. Hard pan with "rusty" gravel	1	6
6. Sand and gravel to bottom of pit	2	..

The material in some of the strata is put to the following uses: Stratum number 2, road and street purposes, concrete, sidewalks. Stratum number 3, plaster finish and sidewalk sand. Stratum number 4, building sand for brick or stone masonry. The price

of this material varies from time to time. At the particular time when this section was made the brick sand was delivered for $1.50 per cubic yard. The stone sand was delivered for $1.25 per cubic yard. Gravel not delivered, 25 cents per cubic yard.

Across the railroad north of the Curdes gravel pit there is another pit just south of the Swinney homestead, of which a section is as follows:

Section of Gravel Pit South of the Swinney Homestead.

	Feet.	Inches.
1. Sand	2	..
2. Gravel	2	3
3. Coarse gravel	2+	..

The gravel from the lowest stratum is a good road gravel, and is used on the walks and driveways in and about Swinney Park. Just south of the Curdes gravel pit is another pit, belonging to J. O. Brown. This pit has been open for seven or more years, and considerable gravel has been removed. The material taken from this pit is used for plastering, concrete, brick work, cement work and masonry. The following section was taken at the southwest corner of the pit:

Section of Gravel Pit Belonging to J. O. Brown.

	Feet.	Inches.
1. Soil, sandy	1	2
2. Coarse gravel with sand	2	..
3. Fine gravel running to fine sand	5	..
4. Stratified bed of sand and fine gravel	5	6
5. Coarse gravel	1	2
6. Coarse sand	..	6
7. Sand and fine gravel	2	8+

At the north end of the Brown pit the following section was obtained:

	Feet.	Inches.
1. White sand, very fine	2	7
2. Sand and gravel	2	..
3. Coarse sand mixed with gravel	8	..
4. Sand and coarse gravel mixed with cobble stone	2	..

In stratum number 3 of the above section the sand and gravel layers dip toward the center of the exposure, forming a basin of some 30 or more feet in diameter. Small pebbles are scattered throughout this exposure. The material in stratum number 4,

Plate V.

(a) View of the exposures at the center of the Curdes Gravel Pit on the west side of the city of Fort Wayne.

(b) View of the exposure at the east end of the Curdes Gravel Pit at the west side of the city of Fort Wayne.

of this material varies from time to time. At the particular time when this section was made the brick sand was delivered for $1.50 per cubic yard. The stone sand was delivered for $1.25 per cubic yard. Gravel not delivered, 25 cents per cubic yard.

Across the railroad north of the Curdes gravel pit there is another pit just south of the Swinney homestead, of which a section is as follows:

Section of Gravel Pit South of the Swinney Homestead.

	Feet.	Inches.
1. Sand	2	..
2. Gravel	2	3
3. Coarse gravel	2+	..

The gravel from the lowest stratum is a good road gravel, and is used on the walks and driveways in and about Swinney Park. Just south of the Curdes gravel pit is another pit, belonging to J. O. Brown. This pit has been open for seven or more years, and considerable gravel has been removed. The material taken from this pit is used for plastering, concrete, brick work, cement work and masonry. The following section was taken at the southwest corner of the pit:

Section of Gravel Pit Belonging to J. O. Brown.

	Feet.	Inches.
1. Soil, sandy	1	2
2. Coarse gravel with sand	2	..
3. Fine gravel running to fine sand	5	..
4. Stratified bed of sand and fine gravel	5	6
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Plate V.

(a) View of the exposures at the center of the Curdes Gravel Pit on the west side of the city of Fort Wayne.

(b) View of the exposure at the east end of the Curdes Gravel Pit at the west side of the city of Fort Wayne.

mixed with screenings from stratum number 3, makes a good road material.

To the southeast of the Brown pit a distance of some two or three hundred yards, and in the northeast quarter of the southeast quarter of section 10 (30 N., 12 E.) is a deposit of gravel where the following section was obtained:

Section from Deposit Southeast of Brown Pit.

		Feet.	Inches.
1.	Soil, sand and gravel	4	..
2.	Layers of sand and fine gravel	1	4
3.	Sand	6	..
4.	Sand and fine gravel	6	..
5.	Coarse sand and fine gravel	5	5
6.	Alternate layers of sand and gravel	3+	..

Stratum number 6 in the foregoing section would make a good stone sand without screening. The upper strata could be used for the same purpose by screening. Stratum number 5 is composed of sand and is well suited for brick work, stone sand and plastering. The sand varies, running from coarse to fine at the top of the stratum. Stratum number 4 would make good stone sand, good brick sand and plastering sand if screened. Stratum number 1 would make good road or street gravel.

At the Gebhart gravel pit, located in the northwest quarter of the northwest quarter of section 22 (30 N., 12 E.), the following section was obtained:

Section of Gebhart Gravel Pit.

		Feet.	Inches.
1.	Sand soil mixed with small gravel	2	..
2.	Alternate layers of sand and gravel	3	6
3.	Sand and fine gravel	1	..
4.	Sand and gravel	1	6
5.	Alternate beds of fine sand and gravel with a dip of about 20 degrees to the south	..	8
6.	Sand and gravel with a rusty appearance	1	4
7.	Hard bluish to drab colored clay, running down to water's edge in St. Mary's River	20	..

The strata 1 to 6, inclusive, in the foregoing section, if mixed together, make a good gravel for road purposes.

To the west of the Gebhart pit a distance of about 200 yards and south of the public road is a deposit of yellowish sand free

from pebbles. This deposit lies in the lowlands, forming a gentle knoll three or four feet in height. The best part of this sand is used in making brick. Here and there are streaks of grayish sand which is unfit for brick making. In the hill to the west of this sand deposit there is quite a heavy deposit of fine sand. This is shown very plainly where the public road cuts the hill.

Following this bank to the southwest a distance of a quarter of a mile or more is the Morrell sand and gravel pit. The gravel portion of this deposit is well suited for public road purposes, but parts of the deposit, especially that lying near the top of the pit, is too fine and contains too much sand to make the best road material. However, these deposits are knocked down and mixed together and used on the roads in the immediate vicinity. Near the Morrell house there is a deposit of yellowish sand which seems to be suitable for brick purposes.

Going west from the Morrell gravel pit there is a continuous deposit of sand and gravel, sand predominating, until the Wabash Railway is reached. Some of this sand and gravel has been removed. At the Rapp pit, in the northwest quarter of section 21, this deposit lies along the north side of one of the abandoned channels of the St. Mary's River, and owes its existence to the high waters of interglacial times.

An examination of the accompanying map will reveal the fact that there are a number of deposits to the south and southwest of the Morrell and Rapp pits. The first of these deposits is located north of the center of the south half of section 20, running east to near the center of the southeast quarter of section 21. In general this deposit consists largely of sand. The ridge rises to a height of 30 or more feet at its highest point above the adjacent lowlands. Some three or four sand and gravel pits occur in this ridge. The Shelling sand pit is located at the west end of the ridge in the southwest quarter of section 20. At this pit the deposit of sand is 12 or more inches in thickness. The sand is fine and heavy, and makes an excellent smelting sand. The large portion of this sand is used at the Bass Foundry in Fort Wayne. Following the ridge east from this pit there is a general increase in the height of the ridge, and the sand changes in its consistency from that of a heavy to a light sand.

Near the center of the southeast quarter of section 20, and just southwest of John Miller's barn is an exposure of coarse sand mixed with gravel. The following well section was reported as occurring at Mr. Miller's residence:

Section of Well near Residence of John Miller.

		Feet.
1.	Sandy soil	5
2.	Sand and gravel	85
3.	Bed rock	1+

Following the ridge farther to the east and just across the northwest quarter of the southwest quarter of section 21, at Charles Gebhart's, there is another sand pit. This sand is also used for smelting purposes. Farther to the east, at Ed Fox's residence, in the northeast quarter of the southwest quarter of section 21, the following well section was reported:

		Feet.	Inches.
1.	Light sand	..	6
2.	Gravel and sand	10+	..

This well is near the crest of the ridge.

South of this ridge, in what seems to be another abandoned channel of the St. Mary's River and some two or three feet below the surface, there is a deposit of gravel. Some of this has been used for the public roads in the immediate vicinity and is well suited for road purposes. To the south of this abandoned channel there lies another ridge which extends from near the center of the southeast quarter of the southeast quarter of section 21 to the west, through the north half of section 29 and into the northeast quarter of section 30. This ridge, which is not as regular as the one lying to the north, is composed of sand and gravel. A number of openings have been made into this deposit, namely, at Wm. Smith's and Graham's, in the southeast quarter of section 21, and at Fairfield's, in the northeast quarter of section 29, and at another point or two toward the west end of the deposit.

A section of the exposed strata at the Fairfield gravel pit, in the northwest quarter of the northeast quarter of section 29, is as follows:

		Feet.	Inches.
1.	Sandy soil	3	..
2.	Fine gravel and sand	5	..
3.	Coarse sand with few small gravel	3	6
4.	Irregularly arranged layers of sand and gravel	3	5

Plate VI.

(a) View of the exposures at the Fairfield Gravel Pit, sec. 29 (30 N., 12 E.)

(b) View showing the screening process at the Brown Gravel Pit at the west end of Taylor street in the city of Fort Wayne.

The sand and gravel of these various strata are mixed together and used on the public roads. This mixture, however, does not make the best road material owing to the predominance of fine sand. Gravel roads from this mixture are quite muddy during rainy weather and dusty during the dry periods of the summer and fall months. Better material could be obtained from this pit in case the sand and gravel were screened, thus eliminating the finer and objectionable parts. Farther to the west in this pit there occurs a layer of clay and sand about seven inches thick. This clay is tough, and when mixed with the other deposits adds to the efficiency of the material for road purposes.

The following well section was reported at Pete Mollet's, in the southeast quarter of the northeast quarter of section 30:

	Feet.	Inches.
1. Black muck	3	..
2. Clay	3	4
3. Quicksand	2	..
4. Gravel	1+	..

In the south part of section 19 and in the northwest quarter of section 30 there occurs a deposit of sand and gravel forming quite an irregular ridge, locally known as Fox Island. The following section will give some idea of the character of this deposit:

Section at Fox Island.

	Feet.
1. Sandy muck	1
2. Yellowish sand	6
3. Quicksand	1
4. Blue clay	1
5. Quicksand	2

To the south and west of Fox Island there are some two or three other small ridges. These smaller deposits, together with Fox Island, seem to have been deposited by subglacial streams or by interglacial Wabash and St. Mary's rivers. To the north of these deposits and following along the north bank of the Erie-Wabash gap there occur a number of light deposits of sand and gravel. A small deposit, known as the Scott gravel pit, is found near the center of the west side of section 24. A small amount of sand and gravel has been taken from this deposit. Farther to the northeast, along the bank at Young's, McMaken's and Junk's,

small deposits occur, some small amount of sand and gravel having been removed from each of these places. Farther to the northeast, and northwest of Lindenwood Cemetery, occurs another small gravel pit. It is probable that quite a large deposit is located at this point. In fact, the indications are that the eastern bank of the small stream located at this place is composed largely of sand and gravel. A few small deposits of sand, with some gravel, are found within the city limits, namely, near the corner of Creighton Avenue and Broadway, south of Scott Avenue, extending west to the Vesey greenhouse, near the Wabash shops, along Calhoun Street, in the block south of the Rich Hotel and near the Pennsylvania roundhouse.

Township 30 North, Range 13 East.

This township lies east and south of the city of Fort Wayne. The sand and gravel deposits are confined to its northern part. The Erie-Wabash gap crosses this township from east to west through sections 1, 2, 3, 4, 5 and 6. The deposits of sand and gravel are confined almost exclusively to the banks north and south of the Erie-Wabash channel. Along the north bank of the channel there is an almost continuous line of deposits passing through the north half of sections 3, 4, 5 and 6. To the south there are few deposits, the only one of any importance lying to the southwest of New Haven. In sections 9 and 10, and south of the Maumee River there are a few sand knolls lying in the lowlands of Maumee Lake bottom. These deposits consist almost exclusively of sand, and have little, if any, commercial value.

In section 7 there are five or more deposits, consisting largely of sand. With one exception these deposits are very small. The one lying farthest to the south is a little more than a mile in length, extending from east to west across the south half of the section. This deposit consists almost exclusively of light sand, and varies in thickness from one to six feet or more. The exposures of this ridge are best seen where it is crossed by the Pittsburg, Fort Wayne and Chicago Railway. Near the center of the west side of section 6 and just east of the public road there is a deposit of sand and some little gravel. The sand lies near the level of the Maumee River, and during high water the pit is flooded. Very little sand and gravel have been removed from this

deposit, both being of an inferior quality. The sand contains too much dirt or soil to make it of any great commercial value. Near the bottom of the pit there are some two feet of sand and gravel.

To the southeast and across the Maumee River, and near the Wabash Railway there occurs another deposit which is composed largely of gravel. This deposit is owned by the city of Fort Wayne. In former years considerable gravel was taken from this pit and used on the streets of the city, but very little has been taken out in recent years. There are some five or more acres included in this deposit. Not all of it, however, contains material suitable for street and road purposes.

At the Catholic Cemetery, in the northeast quarter of the northwest quarter of section 5, the larger part of the soil is a clay soil. However, along the south side of the cemetery there is a deposit of sand with a maximum thickness of six feet. Throughout the other parts of the cemetery clay predominates, varying in thickness from three to four feet. Underneath this coating of yellowish clay occurs a bluish clay, locally known as hardpan.

Following the bank of the Erie-Wabash channel to the east in the northwest quarter of section 4 we find a large sand hill. But very little, if any, gravel is found in this deposit. Farther to the east the sand is displaced by a clay soil. In the northwest quarter of section 3 there is an outcrop of gravel near the Wagenhal residence. At this point the following section was obtained:

	Feet.	Inches.
1. Gravel and clay	2	6
2. Alternate beds of coarse, fine gravel mixed with sand	6	..
3. Sand and fine gravel	3	6+

But very little gravel has been taken out of this pit. In a general way the deposits are not suitable for road purposes, parts being too fine and other parts containing too many large boulders.

Southwest of New Haven and in the southwest quarter of the southeast quarter of section 11 is the I. O. O. F. gravel pit. North of this pit some 200 yards and on the bank of a small stream is the Certia gravel pit, from which considerable material has been taken. The following section was obtained at this pit:

	Feet.
1. Fine sand	8
2. Small gravel with some sand	4
3. Large gravel with coarse sand	4+

A small deposit of gravel occurs along the Findlay, Fort Wayne and Western Railway in the northwest quarter of section 15, but it seems to be of a poor quality.

Deposits along the North Shore Line of the Interglacial Maumee Lake.

As previously stated, these deposits are confined to the shore line of the old lake, and lie in detached masses extending in a broken line from section 35 (31 N., 13 E.) to section 5 (32 N., 15 E.). The heaviest of these deposits are found in sections 25 and 26 (31 N., 13 E.). Quite a number of gravel pits occur at this point and much gravel has been removed. At the Black gravel pit, which lies to the south side of the deposit, the following section was made:

Section at Black Gravel Pit.

	Feet.	Inches.
1. Red sandy clay	1	3
2. Fine gravel	1	..
3. Fine sand	5	..
4. Fine gravel, running to sand and gravel	1	6
5. Coarse gravel	1	4
6. Alternate layers of sand and gravel	3	6

The strata of these exposures are very irregular, running from sand to gravel and vice versa. The predominating dip of the strata is to the south. The exposures at the south side of this pit, if properly mixed, will make a very good road material, but at the north side the material is too fine.

Some 250 yards to the northeast of the Black pit is the Young gravel pit, where the following section was obtained:

Section at Young Gravel Pit.

	Feet.	Inches.
1. Gravelly soil	1	2
2. Dirty gravel	..	2
3. Smooth, round gravel mixed with fine sand	1	8
4. Sandy clay	..	1
5. Medium sized gravel with some little coarse sand	2+	..

Northeast of the Young gravel pit, and located in the northwest quarter of section 25, is the Goeglein gravel pit. The following section was obtained at this pit:

Section at Goeglein Gravel Pit.

		Feet.	Inches.
1.	Red, sandy, gravelly clay	..	½ to 3
2.	Gravel	..	½ to 2
3.	Sand	..	9
4.	Gravel and sand	1	......
5.	Sand and gravel	1	11
6.	Coarse gravel	..	½ to 8
7.	Fine gravel and sand	2	9

The foregoing section was taken at the north side of the pit. Stratum number 4 dips to the west and runs into sand and dirty gravel at the east end of the pit. At the south side of the pit, which is only some 20 feet away, the exposed material is much coarser, forming on the whole a very good material for road purposes.

To the northwest from the Goeglein pit, and just across the section line in section 26, is the Schausee gravel pit. This pit lies at the north side of the wide ridge. The following section was obtained at this pit:

Section at Schausee Gravel Pit.

		Feet.	Inches.
1.	Sandy, gravelly and reddish soil	1	3
2.	Fine gravel and sand	4	..
3.	Clay streak	..	6
4.	Sand and fine gravel; 2 parts sand to 1 part gravel	4	..
5.	Fine gravel and sand	..	2+

Northeast of the Goeglein pit and east of the Maysville road, in the northwest quarter of section 25, is the Meyer gravel pit. The following section was obtained at this pit:

Section at Meyer Gravel Pit.

		Feet.	Inches.
1.	Sandy soil	2 to 3	..
2.	Gravel and sand variable	1	6
3.	Fine gravel and sand	2	..
4.	Coarse sand	..	9
5.	Angular gravel	..	8
6.	Fine gravel	2	..

North of the Meyer pit, in the southwest quarter of section 24, is the Caster gravel pit. A great deal of gravel has been taken from this pit, but at the time of the examination the exposures were covered with loose soil, making it impossible to examine thoroughly the various strata.

Following the ridge to the northeast very few deposits of sand and gravel were found. In the northeast quarter of the northeast quarter of section 18, and in the northwest quarter of the northwest quarter of section 17 (31 N., 14 E.) occurs a small deposit. Some gravel was taken from this deposit years ago, but, the material being of an inferior quality, the pit was abandoned.

Following the lower and less conspicuous ridge to the northeast another deposit is found in the southwest quarter of the southwest quarter of section 4 (31 N., 14 E.). At this point occurs the Miller gravel pit, which lies at the side of the ridge. Here the following section was obtained:

Section at Miller Gravel Pit.

	Feet.	Inches.
1. Black sand	2 to 3	..
2. Coarse gravel	1	8
3. Sand and fine gravel	2	..
4. Covered to blue clay	4	..

The foregoing section was obtained at the south side of the pit. Some 200 yards northeast of the Miller pit is the abandoned Rurtz pit. This pit is located at the eastern extremity of this deposit. Farther to the north, in the southeast quarter of the northeast quarter of section 4 (31 N., 14 E.) is the Wilbur gravel pit. This pit is in a small ridge which lies at the base of the slope leading back toward the road. Here the ridge is very marked. The following section was obtained:

	Feet.	Inches.
1. Gravel and sandy soil	2 to 3	..
2. Fine sand	1	2
3. Alternate layers of fine sand and fine gravel	3	..

This section was taken at the western end of the pit.

Farther to the northeast, in the northwest quarter of section 3 (31 N., 14 E.), is the Werts gravel pit. This lies farther down on the gentle slope of the ridge, which is also true of quite a number of pits in this locality. In a way it seems as though the shore line of the interglacial Maumee Lake receded some 50 yards or more and then remained stationary for some time, building a small secondary beach. The deposits of this immediate locality seem to occur in this small secondary ridge.

Following this beach farther to the northeast the next deposit is found in Maysville, in the southwest quarter of section 28 (32 N.,

14 E.). The deposit occurs in the northeastern part of the township and south of the Maysville road and east of the cemetery. At this point the following section was obtained:

		Feet.	Inches.
1.	Sandy, gravelly soil	1	2
2.	Fine gravel	1	..
3.	Coarse gravel and sand	1	4
4.	Fine gravel and coarse sand	2	3

The foregoing section was obtained at the north end of the pit. The strata in general dip toward the north. Aside from the fine sand found here and there in this deposit the material is well suited for road purposes.

From this point on to the northeast the ridge is less conspicuous and is broken in a number of places by small streams. The highest points of the ridge are some 10 or 15 feet above the adjoining lowlands, while farther to the southwest, in township 31 north, ranges 13 and 14 east, the ridge was well defined, with an average height of some 25 or more feet. It is a notable fact that as the height of the ridge decreases there are fewer sand and gravel deposits.

Near the center of the northwest quarter of section 23 (32 N., 14 E.) is the Zimmer gravel pit. This deposit occurs in the south side of the ridge, which is some 15 feet wide at this point. At this pit the following section was obtained:

Section at Zimmer Gravel Pit.

		Feet.	Inches.
1.	Gravelly soil	2 to 3	..
2.	Fine sand	..	6
3.	Fine gravel	..	2
4.	Fine sand	..	7
5.	Fine gravel	1	8
6.	Covered to bottom of the pit.		

To the northwest of Hall's Corner, near the center of section 13 (32 N., 13 E.), is the Hall gravel pit. From it the following section was obtained:

		Feet.	Inches.
1.	Gravelly soil	2 to 4	..
2.	Gravel and coarse sand mixed	1	6
3.	Sand streak	..	2
4.	Gravel lying in thin layers and dipping to the north at an angle of about 45 degrees	5	..

The foregoing section was taken at the west end of the pit.

To the north and east the material is much finer, with a higher percentage of sand. Farther to the west it is somewhat coarser, and in the main is an excellent material for road purposes. The gravel is highly washed, hard and angular. Along the north side of the deposit there is a streak of quicksand eight inches in thickness. The prevailing dip of the strata is to the north.

In sections 6 and 7 (32 N., 15 E.) there are a few small deposits. Some little gravel has been taken from these deposits, but at the time of examination the strata were covered with soil.

As is seen from the foregoing discussion, the larger part of the sand and gravel deposits lie near the southwest end of the Maysville beach. In general this beach extends as a broken ridge from Lakeside, in the city of Fort Wayne, to the Ohio State line at the northeast corner of Scipio Township. The gravel found in this ridge lies wholly to the south of its center. At the center of the ridge some sand occurs, but in going farther from the ridge to the northwest this sand is soon displaced by a dark, clayish soil.

The ridge lying to the south of the Maumee Lake bottom is not so distinct as the one to the north. This ridge is known as the Van Wert ridge. The highest portion is found south and southeast of New Haven. In following it to the southeast its height greatly diminishes and its width increases. On reaching the southeastern part of the county this ridge is very low and inconspicuous, and a large gap occurs in it where it is crossed by the Big Flatrock Creek in the south half of township 30 north, ranges 14 and 15 east. Very little gravel occurs in this ridge. West of Big Flatrock Creek some two miles, at the end of the broken ridge, there is found a small deposit of sand and gravel. The Tilman gravel pit is located at this point.

East of Little Rock Creek, at the Dudgeon pit, some gravel has been removed. Farther to the east, in section 3 (29 N., 15 E.) a larger deposit is found. Two gravel pits are located in this section—the Roswirn pit, in the northwest quarter of the section, and the Summers pit, near the center of the section.

At the Roswirn pit, in the northwest quarter of section 3 (29 N., 15 E.), the following section was obtained:

Section at Roswirn Pit.

		Feet.	Inches.
1.	Gravelly clay	1	to 6
2.	Washed gravel, running from the size of small shot at the top to the size of marbles at bottom	3	..
3.	Fine gravel and coarse sand	2	..
4.	Brick colored clay	1	..

The foregoing section was made at the center of the south side of the pit.

In a general way the upper half of these deposits is composed of coarse and the lower half of finer material. The gravelly clay on top of the deposit, when mixed with sand and gravel, makes excellent road material, there being enough clay to pack the sand and gravel.

To the south of this pit, in sections 10 and 15 (29 N., 15 E.), three well-defined kames are found. Each of these crosses the state line and extends a mile or two into Ohio. The first kame to the north crosses the state line near the center of the south half of the fractional part of section 11. From a point near the center of the northwest quarter of section 10 it extends toward the southeast to the distance of two miles or more, as reported by the farmers in the neighborhood. It was also reported that Mr. Baker had opened a sand and gravel pit near the western end of this kame. On the whole, the material in this kame is much finer than that found to the north in the Van Wert ridge.

One-fourth of a mile to the west of the state line there is a slight break in this kame. To the south of this a quarter of a mile or more is a second kame, extending to the southeast, but not so long. It has an average height of about five feet, the one on the north being somewhat higher.

A half mile to the south lies a third kame, running in the same general direction as the two to the north, but somewhat longer than either of these. This third kame extends to the northwest into section 16 and is reported to extend about two miles into Ohio. The west end of this kame is somewhat broken and is from three to five feet in height. It seems to be composed almost entirely of sand. The following well sections from a well near the state line will give in a general way the structure of this kame:

		Feet.
1.	Soil	4
2.	Sand	4+

Township 31 North, Ranges 12 and 13 East, and 32 North, Ranges 14 and 15 East.

Considerable sand and gravel is found along the banks of the St. Joseph River, lying some 10 to 30 feet above present drainage. The larger part of this deposit lies in the bank to the east. This is especially true of the deposits found in 31 north, ranges 12 and 13 east. Farther to the north, however, the deposits are in the main on the west side of the stream. This sand and gravel was deposited along the stream by the high waters of interglacial times. The deposits are stratified, with considerable cross-bedding and unconformity. Below is given more or less detailed discussion of these deposits, beginning with the Bair sand pit, which is found just west of the St. Joseph River in the northwest quarter of the northwest quarter of section 5 (32 N., 14 E.), and following the stream south to the city of Fort Wayne.

At the Bair pit but little material has been removed. The deposits consist almost wholly of sand, having a thickness of seven or more feet. The soil in the immediate vicinity of this pit is quite sandy. Southwest from the Bair pit, near the center of the east side of section 6 (32 N., 14 E.), considerable sand and gravel is found. At the east side of this deposit the sand has a thickness of 4+ feet. Following the deposit to the northwest, it thickens, having a total thickness of more than six feet at its center and gradually thinning to the northwest. The width of the deposit east and west runs from 50 to 350 yards. Northwest of the deposit the soil and subsoil consist of a gravelly clay. Across the river from this deposit, north of the wagon road and east of the Wabash Railroad, in the southeast quarter of section 6 (32 N., 14 E.), there occurs a light deposit of highly washed gravel. This deposit lies only a few feet above the level of the stream, and during high waters the pit is flooded. In this way considerable mud is mixed with the gravel. Just south of this deposit some 200 yards occurs a well-defined sand ridge.

Following the stream to the south another deposit is found in the northwest quarter of section 7 (32 N., 14 E.). This deposit lies on the west side of the stream. The following section was obtained at the east end of the pit:

		Feet.	Inches.
1.	Sand	2	..
2.	Sand and gravel	4	6
3.	Sand with some fine gravel	..	8
4.	Sand and fine gravel	4	..

The gravel in this deposit is very hard and angular, and lies in a ridge about 300 yards long, running from east to west. Across the stream at a distance of some 400 yards occurs a well-marked sand hill.

To the southwest, in the northeast quarter of section 12 (32 N., 13 E.), occur a number of sand hills. These deposits are found in main just north of the wagon road and near the east boundary line of section 12, the wagon road crossing one of these sand knolls. Little, if any, gravel is found in these deposits.

North and northeast of Hursh Postoffice for a distance of a quarter of a mile or more sandy soil predominates. Across the stream from Hursh Postoffice the bank is high and composed of gravelly clay. Following the stream to the southwest, the next deposit is found near the center of the south half of section 11 (32 N., 13 E.). This deposit is divided by a small stream into two knolls. It seems as though near the mouths of the small side streams was a very favorable place for the deposition of the sand and gravel. It is quite probable that the present small streams mark the sites of larger interglacial side streams, and that during interglacial times there was a body of comparatively still water just above and below the mouths of these side streams, forming favorable conditions for the deposition of sand and gravel. At this particular point, however, the deposit is not very heavy, as is seen by the following section:

		Feet.
1.	Sand	2 to 4
2.	Gravel	4

The gravel is very hard and shows evidence of much washing.

The next deposit along the stream is found at Leo, near the south side of section 15 (32 N., 13 E.). The following well section was reported at Leo by J. J. Lantz:

Section of Well at Leo.

		Feet.	Inches.
1.	Sand, gravel and clay mixed	3	..
2.	Sand	7	..
3.	Gravel	10	..
4.	Quicksand	1	6
5.	Blue clay	2	..

Just south of the cemetery at Leo there is an old abandoned gravel pit on Henry Hosler's place where the following section was obtained:

	Feet.	Inches.
1. Sand	2	6
2. Gravel	6	..

Just north of the mill dam some gravel was removed years ago, but at present the pit is closed and the deposit is covered with soil. Following the stream south to the center of section 32 (32 N., 13 E.) we reach the Kryder gravel pit. This deposit lies back of the narrow flood plain of the river and at the edge of the second river bottom, just south of a small side stream. At this point the following section was obtained:

Section at Kryder Gravel Pit.

	Feet.	Inches.
1. Sandy clay	2 to 3	..
2. Fine sand	..	6
3. Streaks of sand and gravel	1	2
4. Fine gravel	2	..
5. Fine sand	0 to	2
6. Gravel and sand	5+	..

At the west end of this pit the gravel is much coarser and contains few clay balls. The stratification is very irregular, the strata lying in basins. At the east end of the exposure a number of sand wedges occur. To the west of the wagon road the deposits run into sand.

In and about Leo sandy soil predominates, running back to a distance of a quarter to half a mile. At this point the sandy soil changes gradually into a sandy clay and finally into a pure clay soil.

Across the river from the Kryder pit is the Schwartz sand and gravel pit, where the following section was obtained:

	Feet.
1. Sand	3
2. Fine gravel and sand	2
3. Plastering sand	4

The material at this point is entirely too fine for road purposes. The sand in this ridge changes to clay in coming to the east. The line of demarcation between the sand and clay soil is a very irregular one. No effort was made toward its delineation on the accompanying map, the boundary of the deposit being shown only in a

general way. This is not only true of this particular deposit but also of the various deposits indicated on the map.

Following the stream to the south some few deposits are found along its course in section 27. At the abandoned pit on the John Smoker place some gravel was removed years ago. West from this point and on the opposite side of the stream is the J. Arnold gravel pit, located in the southeast quarter of the northeast quarter of section 28 (32 N., 13 E.). At this pit the following section was obtained:

Section at J. Arnold Gravel Pit.

	Feet.	Inches.
1. Sandy soil with gravel	2	..
2. Gravel and sand mixed	2	2
3. Sand with few gravel	1	..
4. Gravel and sand	1	..
5. Sand	2	4
6. Gravel and sand	2	4
7. Sand mixed with gravel	1	..

Considerable gravel has been removed from this pit, it having been open for 12 or more years. The coarser parts of the deposit when used alone make a very good road gravel, but if the coarser parts are mixed with sand and fine gravel the material is too fine for the best road material. All of it should, therefore, be screened.

One-half mile to the west of the Arnold pit is the town of Cedarville. Considerable sand and gravel is found in and about this place, the sand having an average thickness of about 20 feet. Below this sand and gravel occurs a hard, blue clay. The sandy soil runs north of the town to a distance of about 20 rods, where it is displaced by clay soil. As is shown on the accompanying map, quite a heavy deposit of sand and gravel is found in the angle formed by Cedar Creek and St. Joseph River. The following well section was reported 50 yards northwest of the Arnold gravel pit:

	Feet.	Inches.
1. Sandy soil	1	6
2. Gravel	10	..
3. Sand	2	..
4. Gravel	10	..

Near the mouth of Cedar Creek and on the east side of the St. Joseph River is an abandoned gravel pit on James Zehender's farm. The following section was reported:

		Feet.	Inches.
1.	Rich, sandy soil	2 to 3	..
2.	Gravel	6	..
3.	White, hard pan	..	6+

South of the Zehender pit and on the same side of the stream a number of small sand knolls are found. This is especially true of the south half of section 32 (32 N., 13 E.). Near the center of this section is the Notestine gravel pit. The following section was reported:

		Feet.
1.	Sand and gravel	1 to 3
2.	Gravel	8 to 12

An examination of this gravel showed it to be a hard granite gravel mixed with some little sand and clay, the average size being about as large as lima beans. Near the river the gravel and sand are displaced by a clay deposit, indicating that the gravel does not underlie the lowlands, but that it is a mere pocket confined to the base of the hills. This deposit is poorly stratified. On the hill to the east and just west of the road the sand ridge culminates in a high sand hill, on which there is an old cemetery. This deposit of sand is probably 20 or more feet in thickness. Gravel was reported underneath the sand.

In the southeast quarter of the southeast quarter of section 18 (32 N., 13 E.) is the Hollopeter gravel pit. This deposit lies only a few feet above the level of Cedar Creek and forms a small ridge running from west to east in the lowlands. The high banks north and south of the river valley at this point are composed of a tough, bluish clay. The sand and gravel deposits at this point seem to be confined to the valley of Cedar Creek.

Following the river to the southwest into township 31 north, range 13 east, a number of small deposits are found in this township. In the southeast quarter of the southwest quarter of section 4 (31 N., 13 E.) and on the north bank of the river lies the Cook gravel pit, where the following section was obtained:

		Feet.
1.	Sandy soil	2 to 4
2.	Sand and gravel	8

The lower part of the exposure reveals a number of cross beds. The gravel is hard, highly washed, round and well suited for road purposes. It is impossible to judge accurately as to the extent of

this deposit. The probabilities are, however, that it is only a small pocket.

In the southeast quarter of section 8 (31 N., 13 E.) is the Martin gravel pit, at which the following section was reported:

	Feet.	Inches.
1. Sand and clay mixed	2	6
2. Clay and gravel	15	..

The gravel in this deposit is composed of granite, slate and sandstone mixed with quite a number of clay balls having a diameter of two to eight inches. This clay, together with the slate gravel, makes the deposit a fairly good road material. Farther to the south, in the southwest quarter of section 17, is the abandoned Ashley gravel pit, from which the following section was obtained:

Section at Ashley Gravel Pit.

	Feet.
1. Sand	3
2. Yellow clay	1
3. Gravel	4
4. Clay	1+

At the residence of T. H. Ashley the following well section was reported:

	Feet.
1. Sand	10
2. Clay	10
3. Quicksand	10

Bed-rock was struck at a depth of 140 feet. To the west of this place, between the residence and the river, very little sand is found. The hills are low and composed principally of clay. At places the clay is mixed with some little sand.

Following the east bank of the stream south from the Ashley pit to Fort Wayne there is a more or less continuous deposit of sand and gravel, the sand predominating, with here and there small sand knolls. To the northwest of the Ashley pit, in the southwest quarter of section 7 (31 N., 13 E.), is the Aumen gravel pit, where the following section was obtained:

	Feet.	Inches.
1. Sand soil with few gravel	2 to 3	..
2. Gravel and sand mixed	5	6
3. Blue clay	6	..

The gravel in this deposit is hard, roundish, highly washed and ranging in size from that of a small shot to that of a small marble.

On the whole this deposit makes a very good road material, but unfortunately the deposit is limited in extent.

Northwest of the Aumen gravel pit, in the southwest quarter of section 5, is the Bannet gravel pit. At this pit the following section was obtained:

	Feet.
1. Clay	4 to 5
2. Fine gravel and sand	‹

The material is not suitable for road purposes, and I would advise the discontinuation of its use as long as better gravel is available.

Following this stream across into township 31 north, range 12 east, considerable sand and gravel is found along the stream in the southeast part of the township. In the northeast quarter of section 25 and on the east side of the river is the Blake gravel pit, a section of which is as follows:

	Feet.
1. Sandy clay, which becomes very hard during the summer when exposed	2 to 3
2. Gravel with irregular discontinuous streaks of sand	2

The gravel is highly washed and makes a fairly good road material. This deposit lies in the lowland, which is only a few feet above the river, and extends to the southwest a quarter of a mile. It is quite probable that the level stretch of land is underlain with gravel.

To the northwest of the pit along the small stream and near the Robinson Park street car line there is an exposure of sand and gravel. To the southwest of the Blake gravel pit a distance of half a mile is the Rudisell pit, where the following section was obtained:

Section at Rudisell Gravel Pit.

	Feet.
1. Gravelly clay	2 to 3
2. Gravel mixed with clay	2
3. Fine sand	1 to 2
4. Gravel	1 to 2
5. Sand and gravel	4

A short distance to the southeast of this pit there is a high sand ridge running from the northeast to the southwest and divided into two parts by a small stream. The sand is 10+ feet in thickness,

running into quicksand near the base of the ridge. On the whole the sand is very fine.

In the southeast quarter of section 25 (31 N., 12 E.) is the Hayden gravel pit. South of this pit occurs a number of sand hills, and in the southeast quarter of the southwest quarter of section 25 is the large Hanna pit. This pit is found near the base of the hill. Considerable gravel has been removed. On the whole it makes a very good road material. Farther to the south, near the Institute for the Feeble-Minded, are a number of small sand hills and gravel deposits. To the west of this point, and lying in the lowlands, is a small eskar. Considerable gravel has been taken from this deposit. The following section was obtained at this point:

	Feet.	Inches.
1. Sandy soil	2 to 3	..
2. Coarse gravel mixed with sand	5	6
3. Coarse sand and fine gravel	1	..
4. Small gravel mixed with some little sand	1+	..

The gravel found in stratum number 2 in the foregoing section makes an excellent road gravel. It is highly washed, round and very hard, with enough clay mixed through it to pack it well. In the lower strata the gravel is not so highly washed. South of the Institute for the Feeble-Minded, and following the bank to the east, to the Maysville ridge there is a continuous deposit of sand and gravel. Along the bank in the southwest quarter of section 36 (31 N., 12 E.) the following section was obtained:

	Feet.	Inches.
1. Sandy soil	0 to 2	..
2. Clay mixed with gravel	4	..
3. Sand	2	..
4. Sand and gravel	1	6
5. Sand	2	2
6. Sand and fine gravel	..	6
7. Covered to bottom of pit.		

On Mr. Phillips's lot in the city of Fort Wayne, near the center of the southwest quarter of section 36, there is an exposure of two to three feet of sandy soil, under which there is a deposit of clay and gravel two or more feet in thickness.

Along the second road south of the Institute for the Feeble-Minded a section was obtained, as follows:

		Feet.	Inches.
1.	Sand	1 to 5	..
2.	Heavy sand mixed with clay which hardens when exposed	2	4
3.	Fine gravel and sand, unstratified	3+	..

In general the gravel of this deposit is not suitable for road purposes. If screened it would make a good brick and stone sand.

In the southeast quarter of section 36 (31 N., 12 E.) there are a number of sand knolls and ridges lying along the north bank of the river valley. A number of exposures of this sand are seen in the road running east and just west of the bank. On the north side of the old canal in the south half of section 35 a few local deposits were observed.

Aside from the sand and gravel found along the St. Joseph River there is but little available road material in this township. Some gravel occurs at the following points: In the northeast quarter of section 27, at the Kruse pit; southwest quarter of section 15, on the Solomon place; in the northwest quarter of section 15, on the Hauser farm; in the southwest quarter of section 33, on the Pierce farm, and in the northwest quarter of section 5, at the Fritz gravel pit.

Sand and Gravel Deposits Along the St. Mary's River in Township 29 North, Ranges 12 and 13 East, and Township 30 North, Range 12 East.

Very little sand and gravel is found along the St. Mary's River. The predominating soil and subsoil is of a tough, bluish clay, locally known as hardpan. In sections 21 and 28 (29 N., 13 E.) there is quite a heavy deposit of sand and gravel, the gravel predominating. There are two gravel pits at this point, the Heaton pit and the Wass pit. At the Heaton gravel pit the following section was obtained:

		Feet.	Inches.
1.	Hard, yellow gravelly soil	2 to 4	..
2.	Layers of coarse gravel and sand	3	6
3.	Fine gravel and coarse sand	3	..

The foregoing section was made at the center of the north side of the pit. Stratification is well defined and ran regularly in this deposit. In a general way the material becomes finer in going

from the top to the bottom. The following section was taken at the northeast end of the pit:

	Feet.	Inches.
1. Sandy clay	2	6
2. Gravel with few angular stones	3	..
3. Fine gravel and coarse sand	5	6

A great deal of gravel has been taken from this pit. Considerable of it is taken into Wells County. On the whole the material is very valuable for road purposes, making a very good gravel road.

North of the Heaton pit is the Wass pit. At this exposure the material in the main is finer than in the Heaton pit. At the east side of the Wass pit, where the strata was exposed at the time of examination, there is a marked difference between the coarse material found in the upper half and the finer material of the lower part. The former has a dip of about 30 degrees to the west. An unconformity occurs between the fine and coarse material. At the Wass pit the following section was obtained:

	Feet.	Inches.
1. Sandy clay	1	..
2. Coarse gravel, dirty, mixed with small stone	3	6
3. Fine gravel and coarse sand	5	..

These two pits, the Wass and Heaton pits, open into the same deposit, which lies in a broad ridge extending from north to south. To the east of the deposit there is a small stream, and the slope leading down from the crest of the ridge to this stream is rather steep. On the west side of the ridge the slope is gentle and no well-defined line marks the boundary of the ridge.

In the northwest quarter of section 7 (29 N., 13 E.) is the Maloon gravel pit. The following section was obtained at this exposure:

Section at Maloon Gravel Pit.

	Feet.	Inches.
1. Gravelly, sandy clay	2 to 3	..
2. Layers of coarse and fine gravel, alternating	5	6
3. Fine gravel with some coarse sand	4	6

Considerable gravel has been taken from this pit. It is clean and comparatively free from fine sand, making an excellent road material. The deposit lies along the bank leading down to the level land along the river. The strata dip to the northwest toward the river at an angle of 30 degrees. It seems to be only a pocket

of gravel, evidently deposited by the high waters of interglacial times. But little gravel is found in township 29 north, range 12 east. The heaviest deposits are found at the Harbor pit, in the northeast quarter of section 12, and at the Dalman pit, in the southwest quarter of section 8.

At the Harbor pit the following section was obtained:

	Feet.	Inches.
1. Gravelly, sandy clay	3	4
2. Poorly defined, alternate beds of coarse sand and gravel.	6	..

This material is considerably finer than that found at the Maloon pit. The strata dip to the west and northwest. This sand and gravel was also deposited by the high waters of interglacial times, and lies somewhat higher than the sand and gravel at the Maloon pit. At the Dalman and Harbor pits the deposit was not so heavy, and forms a narrow ridge running along the west side of Lost Creek. But little gravel has been taken from this deposit, as only four or five feet lie above present drainage. The prevailing soil and subsoil of this township is a tough clay. Reported well sections indicate that the drift here runs from 60 to 80 feet in thickness.

An abandoned river channel crossing township 30 north, range 13 east, from St. Mary's River to a point two miles southwest of New Haven, indicates that during interglacial times the St. Mary's River left its present channel in section 7 (29 N., 13 E.) and flowed to the north through sections 5, 32, 29, 20, 21, 15 and 16 (30 N., 13 E.), emptying into the interglacial Maumee Lake at a point just south of where New Haven now stands. This channel is very conspicuous, having in general a width from a quarter to half a mile, with well-defined banks rising in height from 15 to 25 feet above the intervening lowlands. Further evidence of this interglacial position of the St. Mary's River is seen in the delta formed at its supposed mouth. This delta, known as the New Haven delta, has a length east and west of four miles and a width north and south of about one mile. The outline of the delta is well defined, consisting mainly in irregular banks extending through sections 7, 8, 5 and 6 (30 N., 14 E.). On the accompanying map the outline of this delta is indicated by a dotted line. The delta is composed largely of sand and fine gravel, with the sand predominating. A number of small sand knolls occur near

its eastern extremity. One mile east of the east end of the New Haven delta, in section 9 (30 N., 14 E.), is the west end of a long ridge, locally known as "Irish Ridge." Considerable gravel is found in the west end of this ridge. Farther to the east, as previously stated, the ridge decreases in height and is less conspicuous.

Two gravel pits occur in the west end of this ridge, namely, the Voirol and the Baudelier pits. At the former a section disclosed the following:

Section at Voiroil Gravel Pit.

	Feet.	Inches.
1. Gravelly and sandy soil	2	4
2. Fine sand	1	6
3. Yellow clay, sand and gravel mixed	1	4
4. Sand and fine gravel, poorly stratified	2	4
5. Blue clay	1	..

The strata in this exposure are very irregular, no one stratum running the full length of the exposure. A very marked unconformity occurs between strata numbers 3 and 4. Farther east in the exposure stratum number 4 runs into a bed of sand which contains only a few pebbles. The dip of the strata below number 3 is to the east, while the dip of the strata lying above number 3 is to the northwest. This pit is near the center of the ridge. A great deal of gravel has been taken from these two pits. On the northeast slope of the pit the exposure consists almost wholly of gravel and coarse sand, and at this point the strata lie in a more horizontal position. Men working in the pit at the time of the examination reported that the deposit runs very irregular, changing abruptly from coarse gravel to fine sand.

South of this ridge or kame one and a half miles is the Van Wert ridge, which extends across the township from the northwest to the southeast. This ridge is very prominent at the west side of the township, but gradually decreases in height toward the east, being some four feet in height at Four Corners, while at the west side of the township it has an average height of about 18 feet above the adjacent lowlands. In this township the ridge appears to be free from gravel. Some few conflicting reports were given with reference to gravel deposits by the farmers along this ridge. From observations made in the field it is safe to say that but little, if any, gravel is found in the ridge in this township.

Township 29 North; Range 11 East.

The sand and gravel deposits are confined to the southwest corner of the township, where some four pits occur. In section 36 there is an abandoned gravel pit known as the Knight pit. At the time of the examination the gravel was covered with soil. Favorable reports were given with reference to the quality of the deposit, which is apparently 15 or more feet in thickness, and lies in the acute angle formed by the small stream and Eight Mile Creek. Just north of the Knight pit, where the wagon road leads down to the bridge, gravel is exposed. It is quite probable that considerable gravel is found along the banks of Eight Mile Creek. However, few openings have been made into these deposits.

At the Wilson pit, in the northeast quarter of section 30, some little gravel has been removed. The strata at this point were also covered at the time of the examination. North of the Wilson pit, across the public road, in the southeast quarter of section 19, is the McFirn pit. At this place the deposit seems to be a local pocket located at the end of the point of land between the two small streams.

The topography of this township is quite broken, especially about Zanesville and along Eight Mile Creek and to the north along the Erie-Wabash channel. East of Zanesville the land lies some 875 feet above sea level. The various heights at this point are indicated on the map by numbers. This is also true of quite a number of other points in the township. These lines of levels were run by an aneroid barometer.

Another set of numbers on the map indicate the thickness of the glacial deposit.

Township 30 North, Range 11 East.

The deposits of this township are confined to the banks of the Erie-Wabash channel and Aboit Creek. A number of small deposits occur along the north bank of the Wabash channel, the largest of which is found in sections 32 and 33. The Ambler, Blair and Rosseau pits occur at this point. The following section was obtained at the Ambler pit:

	Feet.
1. Soil	3
2. Gravel mixed with clay	10

Farther to the west, near the boundary line between Allen and Huntington counties, is the Suter gravel pit. This deposit consists of a low, wide ridge extending from the county line east half a mile or more. A section at this pit showed as follows:

	Feet.	Inches.
1. Soil and gravel	1	6
2. Coarse gravel	4	..
3. Gravel and sand	2+	..

This deposit is unstratified and much coarser than the average deposit throughout the county. The following well section will give an idea as to the depth of this deposit:

	Feet.	Inches.
1. Soil and gravel	1	6
2. Gravel	28	6+

The crest of this ridge is some 10 or 12 feet above the level land to the south. The ridge has the appearance of a small drumlin. The west end extends across into Huntington County some 50 or 60 yards. At the northeast end of the ridge there is a spur extending northeastward to the hills. North of this ridge some gravel has been taken from near the foot of the hills.

Following Aboit Creek north there are three or more deposits along this stream in this township—the Orr pit, in section 20, Knepper pit, and the Stouder and Craig pits. The Stouder and Craig pits, however, are not directly along Aboit Creek, but lie half a mile or so back from the stream along the banks of a side stream. All these deposits seem to be quite small, and in the main the material is not the best for road purposes.

To the west of Aboit Creek, in the northwest quarter of section 19, is the abandoned Esterline pit.

Township 31 North, Range 11 East.

But very little gravel is found in this township. In the northwest quarter of section 31 is the abandoned McGrath pit. This deposit lies in the lowlands, and at the time of the examination the exposures were covered with soil. The following section was reported:

	Feet.
1. Soil	2 to 4
2. Gravel and sand	5
3. Blue clay	1+

Near the center of section 10 a small island of sand and gravel occurs. A section of this deposit was reported as follows:

		Feet.
1.	Clay	3
2.	Gravel and sand	3 to 5
3.	Blue clay	1+

This deposit lies in the lowlands of the lake region of this township. In general the land of the township is low and swampy, with a number of lakes, Everett Lake being the largest.

Township 32 North, Range 11 East.

What little gravel is found in this township lies along or near Eel River. Three abandoned pits occur near Old Hellers Corners. These are the Baxter, the Bennett and the Johnson pits. At the Johnson pit the following section was obtained:

		Feet.
1.	Sandy, gravelly clay	1 to 2
2.	Coarse gravel, with few streaks of fine gravel and coarse sand	2
3.	Fine sand mixed with few gravel	2+

There is considerable variation in the character of these deposits. The following section was obtained at the east end of the pit:

		Feet.
1.	Sandy soil	1 to 3
2.	Very coarse gravel	9

The material found in this deposit is probably the coarsest in the county. A large number of boulders are mixed with the gravel, which vary in size from two to five inches in diameter. In removing the gravel for road purposes a number of these boulders are thrown out at the pit, but quite a number of the smaller ones are hauled out and thrown upon the road, making a rather rough surface.

A section at the Bennett gravel pit showed as follows:

		Feet.
1.	Sandy loam	1 to 3
2.	Very coarse gravel	5+

The material in this deposit is very poorly stratified. The dip is to the west at an angle of 15 to 20 degrees. The gravel is hard, roundish, variable in size, and lies in a fairly well defined ridge running from the northeast to the southwest, with a total length of about half a mile. Considerable of the gravel taken from this pit is hauled into Lake Township.

Township 32 North, Range 12 East.

The deposits of this township are confined to the region in and about Huntertown and along Cedar Creek. Heavy deposits of sand and gravel are found in and about Huntertown, the sand predominating, in and to the southwest of the town. To the northeast of Huntertown the deposit contains more gravel. At the Parker gravel pit, which lies half a mile northeast, the following section was obtained:

Section at Parker Gravel Pit.

		Feet.	Inches.
1.	Sand and gravel	2 to 4	..
2.	Sand	1	2
3.	Coarse gravel mixed with coarse sand	1	..
4.	Fine and coarse gravel mixed with coarse sand	2	8
5.	Fine gravel with coarse sand	3+	..

Stratification is well defined in this deposit. The gravel is hard and roundish. Certain parts of the deposit, however, contain too much sand to make a good road gravel, and all should be screened. Just north of this pit, lying in what seems to be an abandoned channel of Cedar Creek, occurs some four or five sand hills. To the northeast, in the northeast quarter of section 9, in the angle formed by the small stream and Cedar Creek, is quite a heavy deposit of sand and gravel. On the whole, the material found at this point is coarse and the gravel is hard, roundish and highly washed. Considerable gravel has been removed from this deposit. The pit here is known as the Fitch pit. One mile to the north, along Little Cedar Creek, is another pit, also known as the Fitch pit. This lies east of the creek and just south of the public road. The following section was taken at this point:

		Feet.	Inches.
1.	Sand	4	..
2.	Sand and gravel	5	..
3.	Fine gravel and coarse sand	3	..
4.	Streaks of sand		1 to 2
5.	Coarse sand and gravel	3	..
6.	Streaks of sand	..	2
7.	Coarse sand and gravel	4+	..

From along the west bank of Cedar Creek some little gravel has been taken. To the east of Big Cedar Creek and lying along the public road are also a number of deposits.

Farther to the north, near the county line, is the Krauter pit. At this point the land is very broken, and in the lowlands along the streams a number of knolls and irregular ridges are found. These knolls and ridges usually contain considerable gravel and sand, the gravel predominating.

A mile east of this point is "Dutch Ridge," a very high, broken ridge with an average height of about 50 feet above the lowlands. The highest point in this ridge is 930 feet above sea level, and is the highest point in Allen County. The relief of the north half of this township is very broken. High banks are found along the sides of Little Cedar Creek and Cedar Creek. As previously stated, it seems as though Cedar Creek at one time left its present channel at the northeast corner of section 9 and flowed to the southwest, emptying into Eel River. Later, however, and for some cause not yet fully determined, the stream changed from its former channel and turned to the southeast across the second Erie moraine, uniting with the St. Joseph River where Cedarville now stands. A deep gorge of from 30 to 50 feet has been cut out by this stream. Through the terminal moraine the banks of the channel are usually steep and irregular, the valley of the creek varying in width from a quarter to half a mile.

* * *

The following information regarding the improved roads of Allen County was furnished by Mr. M. A. Ferguson, Ex-County Commissioner:

One-half, or 450 miles, of the public roads of Allen County are gravel roads built by the township trustees and volunteer work by the farmers, at an average cost of $1,000 per mile. These include 50 miles of toll roads purchased by the county in 1897 and 1898. This plan of road improvement was commenced in 1887, and has continued up to the present time.

There is a growing sentiment among our people in favor of permanent macadam roads, using our gravel roads as a foundation and finishing with broken stone, which would have to be shipped here at a cost of $1.00 per cubic yard.

In the early 50's there were about 50 miles of plank toll roads built in the county, but this experiment was not a success. Later there were five gravel toll roads constructed in the county. The

plank roads were abandoned and the gravel toll roads were finally purchased by the county and made free county roads. Since 1896 there have been 185 miles of gravel roads accepted by the commissioners and maintained as county roads.

There have been no roads built in the county under what is known as the "two-mile law" in the last 25 years, and consequently there are no specifications available for building improved roads.

What I believe to be the essential requisites for a permanent road in a level country, such as we have in this part of the State, are: First—Thorough drainage. Second—Proper material. Hard, blue limestone is the only available material to be had in this county at a reasonable cost. Third—Proper construction. The roadbed or foundation should be rolled down with a heavy roller until it is compact and solid, and each course of broken stone should be treated in the same manner. Two-thirds of the broken stone that is usually used will make a better road, if applied in this manner, than will the full amount if used as is commonly the custom.

SECTION VIII.

THE ROADS AND ROAD MATERIALS OF PORTIONS OF CENTRAL AND EASTERN INDIANA.

EMBRACING THE COUNTIES OF RANDOLPH, WAYNE, UNION, FAYETTE, FRANKLIN, RUSH, HENRY, DELAWARE, MADISON, HANCOCK, HAMILTON, TIPTON, CLINTON AND BOONE.

BY A. E. TAYLOR.

The area treated in this section comprises about 4,850 square miles of central and eastern Indiana and embraces the counties above mentioned.

In these counties probably no one factor has had a greater influence in making them one of the best agricultural districts of the United States than the improvement in roads. In every way the farmer has been benefited by this improvement. His younger children during the wet and muddy seasons formerly had to remain at home on account of the mud, but today find a good path to the district school by way of the improved road. The older children, who would have had to leave the home and its influence and board in town or else discontinue their education, can now drive with ease to the high school five or six miles distant. The farmer himself, who formerly could not get his crops to the market except when the roads were dry, when the market prices were low and work on the farm was at its maximum, can now put them on the market when the prices are at their best. Since the marketing and chores make up the main part of his work, he can with comfort drive across the once seldom attempted barrier to his neighbors and learn the secrets of their success, and give his in turn; and to the Farmers' Institutes, where the most practical agricultural problems of his day are carefully considered; and with his family to the neighboring towns or cities in order that he may attend a lecture course or other social gathering. The Rural Free Delivery system, which is almost wholly confined to the im-

proved roads, brings him, by means of the newspapers, into daily contact with the outer world. This not only affords him with the weather forecast and other information which is of great economic importance, but acquaints him with the progress of the entire world. It provides him with many important lessons in current history, sociology, political economy and other lines, which he and his family can talk over as they gather around the comfortable fireplace during the long winter evenings.

Besides these splendid effects upon the society and availability of markets, good roads have increased the price of land. In the country well-to-do people seek those localities where the transportation is best. It is this that has caused so many to come from Illinois and parts of Indiana where the roads are mainly dirt and buy at a good price the farms along the improved roads in this portion of the State. This increasing demand for farms has greatly increased the price of land during the past fifteen years.

Kind of Road Materials.

In this area the available road materials are gravel and limestone. The gravel, as the writer will generally use the word, will include, strictly speaking, the following: (a) a fine medium sand one one-hundredth to one-fortieth inches in diameter; (b) a medium sand one-fortieth to one-eighth inches in diameter; (c) a coarse sand one-eighth to three-eighths inches in diameter; (d) a roofing pebble three-eighths to seven-eighths inches in diameter; and (e) a gravel seven-eighths to two inches in diameter. Anything larger will be termed a boulder, and any sand smaller than one one-hundredth of an inch will be known as a fine sand. Only when the word gravel is used to mean the percentages of the various sizes of material in a deposit will it mean from seven-eighths to two inches. We would say, for example, ten per cent. coarse sand, fifty per cent. roofing pebble, thirty per cent. gravel and ten per cent. boulder.

Origin and Distribution of Gravel.

Gravel is found to some extent in every part of this region with the exception of that part of Franklin County which is southwest of White River and its west fork. It occurs in both fluvial (stream deposits) and glacial deposits.

The fluvial deposits, which make up by far the larger per cent of the gravel of economical importance, are found in the beds, flood plains, terraces and bluffs of all of the streams. They are also found in numerous old stream courses which have been entirely filled up during and subsequent to the recession of the ice sheet. These fluvial deposits can readily be recognized by their stratification and the uniform size of the material in a particular stratum. The forming of such deposits is brought about by the streams and their tributaries picking up the glacial drift that covers this area from their sides and bottoms. The picking up is done especially at the time of flood, because then the stream has enormously greater power of transportation. This transportation power varies as the *sixth power of velocity. In other words, a stream which could move a cube of one inch would with twice the velocity move a cube of four inches, or sixty-four times the volume, because twice the amount of water, with twice the velocity, will strike the face of the cube in the same time. After the loads have been gathered up by the millions of little streams found on the hillsides, in the roads and almost every place, deposition commences. The temporary stream of the hillside succeeds in getting a small supply of clay, sand and gravel to the little brook, which is now swollen to its utmost. The brook may deposit its boulders and coarser material, but succeeds, with its steep gradient and consequently great velocity, in getting a large portion of its load to a larger stream which has far overflown its banks. This creek is already loaded, and this extra amount necessitates its getting rid of some of its material. Which will it be? Physicists tell us that the draught on a stream's energy of a particle carried in suspension is measured by its mass into the distance it would fall in a unit of time in still water. It follows that a large particle will make a greater draught on a stream's energy than the same amount of material in smaller pieces. Thus it is evident that a stream will deposit the coarser material first; the coarsest will be deposited where the velocity is greatest and the finest where it is least. So we get boulders under the stream current, gravel just outside of the current, coarse sand beyond the gravel, and finally silt at the borders of the flood plain. When the velocity becomes

*For a fuller discussion of this law see Chamberlain and Salisbury's Geology, Vol. I, pp. 109-110.

less, coarse sand is deposited over the gravel and medium over the *coarse. True, the next flood may pick up much of this material, but finally the meanderings of the stream will so change its flood plains, currents and channel that considerable will remain as a flood plain deposit.

The terrace deposit is an outgrowth of the flood plain deposit, and is brought about in the following manner: The valley or flood plain is developed where the steep gradient of the stream's course gives away to the gentler. †This development begins at the head of the valley. As the head of the stream works back into the land this junction of steeper and lesser gradient advances farther up the valley. When the advance has been considerable, the stream on reaching the head of its valley plain deposits so much of its load that it is able to degrade its channel farther down stream. At a later stage in the stream's history erosion becomes less at the head, a smaller quantity of material is carried and the channel is deepened. A stream in the flood plain stage is likely to meander, and this meandering is in a plain which is generally more narrow than that of the valley plain. The cutting of the stream channel and the widening of the meandering plain soon makes it possible for the floods to keep within the new plain, and in this way the old flood plain is left as a terrace above the new or meandering plain. This is a very brief account of the normal way in which terraces are built from the flood plains.

In this particular region a very rapid building up of the valley plain took place when the melting ice from the front of the Wisconsin ice sheet formed great floods, which were heavily loaded with glacial drift; and it was the deposition from this increased supply that built the flood plains high upon the sides of the valleys. Subsequently the ice retreated, the excessive supply became exhausted and the streams were no longer loaded. At this stage a rapid cutting commenced. The outcome has been some of the high gravel terraces in some of the larger valleys of today. We can also see how the rising of the surface might also develop terraces.

The bluff deposits are in general the remnants of old terraces which erosion has cut away.

*See illustration on page 413.

†For the development of terraces see Chamberlain and Salisbury's Geology, Vol. I, pp. 193-201.

Next to the fluvial deposits in economic importance are the glacial. These occur in kames, terminal moraines, recessional moraines and in the ground moraines. In some form these deposits occur throughout this region with the exception of the area of Franklin County previously mentioned. Almost all of these deposits can be recognized by the clay, sand, pebble, gravel and boulders being confusedly commingled, no assortment of material, as is the case with the stream deposits, being present. Much of the material is angular, with planed faces having the parallel markings known as glacial striae. The material is not the product of rock decay, but rather of rock grinding. Furthermore, the topography of these deposits are not due to stream erosion, and occasionally are not even as much as drained by the natural water courses of this area.

Any one who has examined this glacial drift can at once tell that it is made up of a very large per cent. of the country rocks, which are limestones, shales and sandstones, and a number of foreigners, such as granite, diorite, syenite, andesite, basalt, quartz, quartzite, slate, etc. How did these foreigners get here? No rocks of this nature are found in place nearer than northern Michigan and central Wisconsin. The only rocks in place in this area are the limestones, shales and sandstones. So it follows that these foreigners must have been transported several hundred miles. This transportation was brought about by the last great ice invasion, known as the Wisconsin, which picked up a portion of the material that it ground beneath it and carried a low per cent. to this area. In the meantime it had picked up a large amount of the bed rock material in Indiana, which became heterogeneously mixed with the foreigners and was thus deposited.

Of the various types of glacial deposits the terminal moraine is the accumulation which takes place at the end of the ice sheet. This accumulation is generally pronouncedly more conspicuous than other moraines, because it is formed when the movement forward and the melting of the ice are almost equal. During such a halt at the front of the glacier the advancing ice carries its debris to the front, where it may accumulate for some time. When finally the ice all melts away a ridge, rising above the adjacent country, is left. The recessional moraine is formed in a similar manner, except that the halting point is not at the greatest extent

of the ice sheet, as in the case of the terminal moraine, but rather in the receding stage. The kames in these counties are generally associated with the terminal or recessional moraines. They are commonly formed by the water of an ice channel ending against a terminal or recessional moraine and here depositing its heterogeneous load. This gives rise, after the ice has melted, to the peculiar knoblike form. Eskars are developed by streams of considerable size under or in the ice sheet. Because of their heavy load, a portion is deposited in their channels, which on the melting away of the ice leaves a long ridge. The ground moraine is formed when the glacier is in its retreating stage, being the general distribution of drift over this area, covering all of the surface that the terminal and recessional moraines do not, except for the barren area in Franklin County.

The terminal moraine enters Indiana from the east, in southern Randolph and northern Wayne counties. Here it is from six to eight miles wide, and forms the watershed between White and Whitewater rivers. Its surface contains some kames, south of Lynn and Spartansville, which range from 25 to 50 feet high. In southeastern Nettle Creek Township a portion of this moraine turns south into Wayne County. At Dalton this moraine is 200 feet above Nettle Creek and contains kames on its summit. It continues in a southwesterly direction through Henry County, where it is found in Blue River, Stony Creek, Prairie and Jefferson townships. The writer noticed the kame deposits to be very well developed in southern Stony Creek and central Prairie townships. Some very good gravel deposits are found in these moraine hills, which will be described under the counties in which they occur. Other parts of terminal and recessional moraines where gravel is found in workable quantities are found 4 or 5 miles northeast and 5 or 6 miles west of Rushville, from 2 to 8 miles northeast of Muncie, 3 or 4 miles south and 3 miles east of Anderson, 7 or 8 miles southwest of Noblesville, 4 miles northwest of Greenfield and 6 miles southwest of Thorntown. In all of these counties workable deposits are found in the ground moraine.

Quality of Gravel.

The quality of gravel is determined by its rock composition, amount of oxidation, size and character of the cementing materials.

The rock compositions of the gravel in this area are in a general way very similar. Probably an average composition, exclusive of clay, is 85 per cent. limestone, 10 per cent. crystallines, 2 per cent. shale, 1 per cent. slate, 1 per cent. chert, ½ per cent. argellite and ½ per cent. sandstone. By crystallines I refer to those rocks which are made up of crystals, such as granite, syenite, diorite, gabbro, andesite, basalt, gneiss, schist, peridotite and quartzite.

Maximum, minimum and average results on rock samples, corrected to January 1, 1906, by the Agricultural Department of the United States are given on page 69. This table shows us that the crystalline, chert and quartzite stand very high in quality as road materials, limestone considerably lower, slate lower than the limestone and the shale lower than the slate. The percentages of shale and slate are higher in the western portion of this area, which tends to make that gravel rather inferior.

All gravel which is above the ground water level is oxidized to some extent. In other words, the oxygen of the air unites with the constituents of the rock, causing it to be changed to an oxide, which is the weathered or rotted form. The amount of oxidation depends upon the length of time that the material has been exposed to the air, the rock composition and the size. In a deposit the material nearest the surface is invariably leached; but this condition becomes less and less as the rocks are farther beneath the surface, until ground water level is reached, beneath which they are not noticeably affected. The crystallines ordinarily do not weather as readily as the limestone, but in some cases very large boulders are quite rotten on account of long exposure before the glacial transportation. From an economic point of view too much importance can not be laid on oxidation. Material which is below the level of ground water is claimed by commissioners, trustees, road supervisors and road superintendents to outwear the material above this level from 2 to 3 times.

Closely related to oxidation is the size of the material. A fine

grain, when it has taken on a film of oxidation, has become almost entirely oxidized, while with a coarse gravel we have the opposite. Furthermore, a fine grain has already reached the size that the coarser material gets to after much wearing. As a matter of fact, it is known that the coarser material makes a far more durable road than the fine.

The durability of a road is also dependent upon the cementing qualities of the gravel. Creek gravel which contains no cementing materials is invariably working off at the sides of the roads unless almost constant grading is done; and it is with difficulty that loads are hauled through it. It also grinds up into powder and blows away much more rapidly than when there is a cement to hold the particles in place and cushion them from one another.

The principal cementing or packing substances that are found in these gravels are, in the order of importance, fine calcareous conglomerate, calcareous clay, slightly calcareous clay, and dirt. The first is a white crustlike material containing grains of fine, medium sand and filling up the interstices in the gravel bed. In some pits the gravel is so held together by this cement that it comes out in great masses, which have to be blasted apart. Gravel containing this material when put on the road becomes quickly cemented and makes an exceptionally durable and smooth road. The very calcareous clay is generally sticky and of a bluish color. It also serves to hold the material in place, and helps to make a road durable. The slightly calcareous clay and the dirt are far ahead of nothing. The amount of clay in a deposit should be from 7 to 15 per cent. A greater quantity than this causes the roads to be dusty in the summer and rather muddy in the winter.

Availability of Gravel.

Another factor of considerable practical value is the availability of the material, which is determined by the quality, quantity of stripping, transportation and amount of impurities. Unless the material is of a good wearing quality, of a fair size and not too much weathered it is almost a waste of time to put it on the road. Where material ranges from a flaxseed to a wheat grain, and is also considerably oxidized it would be much cheaper in the long run to have crushed stone shipped in, which would outwear such

gravel 4 to 5 times. The quantity of gravel necessary to build 1 mile of road with a width of 10 feet and a depth of 14 inches is 2,000 cubic yards, or a bed 40 yards long, 20 yards wide and 2½ yards deep. A deposit in this report will not be termed workable unless it contains 10,000 cubic yards. The amount of stripping that can be removed is governed by the depth and extent of material beneath it. For instance, 2 feet of stripping might be removed for 20 feet of gravel if the extent would be sufficient to pay for opening such a pit. The amount of transportation necessary to get the material from the pit to the place that it is to be used is a very essential matter. In some parts of this area the gravel is hauled as much as 6 or 7 miles. In such cases not over two loads can be hauled per day, which means that the transportation alone costs about $1.25 per cubic yard. Under such circumstances careful estimates should be made as to the cost of crushed limestone delivered to the nearest railroad crossing. The limestone will outwear the gravel from 2 to 4 times, and could probably be put on the switch for less than a dollar per yard. Frequently a very good gravel can be gotten at a reasonable rate in a similar manner. The hauling from the pit to the public highway is often a very difficult task. Here the wear on the horses and wagons is greater than in all the rest of the distance put together. Commonly, this distance will be as much as a half or three-quarters of a mile over very soft and rough ground. Under such conditions very careful estimates should be made by inquiry of those who have hauled under similar circumstances, as to the cost and labor. The amount of waste material that has to be worked around or thrown aside is, especially in the case of gravel deposited by the ice sheet, very great. If 50 per cent. of a deposit is clay, and this is mixed all through the gravel it is useless to attempt to work it. In opening up a deposit such a difficulty may be easily avoided if the stripping be removed with a post hole auger and then an iron pipe 1½ inches in diameter and from 10 to 20 feet long be driven down at a number of points into the bed. By then removing the material from the pipe one can see just what the quality of the gravel is. When one has had some practice in driving a pipe he can tell by the way it goes down and turns, almost with exactness, what material he is in, and does not have to remove it until he has driven it as far as he wishes.

Machines for Securing Gravel.

To raise the gravel from beneath the ground water level three machines are at present being used in central Indiana, viz., (1) the Gravel Excavator, (2) the Endless Chain, and (3) the Gravel Pump.

The Gravel Excavator.—The equipment necessary for this machine is a steel bucket which will hold one yard of gravel, 500 feet of 1¼-inch Lockwin cable; one pole, known as a mast, 50 feet high; a three drum hoisting engine, with 16 horse-power on either side, and a 25 horse-power boiler.

Before this apparatus is set for operation an area of 50 by 200 feet is carefully tested by driving a 1½-inch pipe. If a depth of 15 feet or more of gravel is found to underlie this area the mast is set 100 feet back from the one end of the area and an anchor 100 feet back of it. Back 25 feet from the other end a 25-foot pole is set and an anchor 60 feet farther. Over the tops of the mast and pole and fastened to the anchors, the cable is stretched. The space intervening between the mast and the area to be excavated is where the material is to be dumped, and that between the pole and this area is where the boiler and engine are set. The bucket is suspended by pulleys to the 1¼-inch cable, and by means of smaller cables and pulleys can be lowered at any point beneath the 1¼-inch cable in the area to be excavated. Upon being lowered to the gravel bed it is dragged in the gravel until filled, when it is lifted by the cable and carried to a place immediately above the dumping area, where it is dumped by means of a trap door. The bucket then returns and the operation is repeated.

In this dipping process all the material of the deposit is taken out, clay and fine sand as well as gravel. For this reason the gravel has to be of a good character before a gravel excavator can be used. The stripping, if more than 4 or 5 inches, is always removed unless the gravel is exceptionally free from clay. The daily capacity of this machine is from 100 to 200 cubic yards, 125 yards being an average. The cost of lifting a cubic yard ranges from 15 to 25 cents, depending upon the stripping and amount of gravel taken out in one setting.

The Endless Chain.—This machine is composed of a number of little buckets which make up part of the links of the chain.

These buckets have a capacity of 125 to 150 cubic inches. They are opened at the top and bottom so that a good circulation of water passes through the material which they contain when they are being dragged over the gravel bed. This circulation washes out a large part of the clay, dirt and fine sand. Besides the chain there must be a 15 to 20 horse-power engine and boiler, and a mast. The length of the chain and the number of buckets are governed in accordance to the length of the pit, more buckets being added or taken out to satisfy the conditions.

Like with the gravel excavator, an area of about 50 by 200 feet is tested. If there is 9 feet or more of gravel the chain is fastened to a shaft, which is connected to the engine, at the one end and to a pulley at the top of a mast, which is about 25 feet high and 60 feet back from the area to be excavated, at the other. As the filled buckets come up out of the pit and pass over the pulley and the top of the mast the loads are dumped, and they return, repeating the operation. By this process from 50 to 80 cubic yards are taken out daily at a cost ranging between 15 and 25 cents each. No stripping has to be done, the dirt being allowed to fall into the pit and wash out through the gravel. Frequently pits that contain entirely too much clay for a gravel excavator can be worked with great success by this apparatus because of the washing out of much of the finer material.

The Gravel Pump.—With the gravel pump pipe tests of the area underlain by gravel are made. If a depth of 6 feet or more of gravel are found with an extent of 30 by 100 feet the pump and a 12 or 15 horse-power boiler and engine are set. This apparatus pumps out the gravel, fine sand, clay and water together. The output is from 30 to 50 cubic yards per day. The gravel pump does not seem to give as good satisfaction as the excavator and endless chain.

LIMESTONE OF THE AREA.

Limestone, although present in great quantities in parts of the eastern two-thirds of this area, has not to any great extent been used up to this time except in and near cities, because of the availability of the gravel. However, the rapid exhaustion of the sup-

ply of gravel in many localities is bringing this durable road metal more and more into use.

In this area is found the Niagara (Silurian) and Cincinnati (Ordovician) limestones. The first outcrops in northern Randolph and central and northern Delaware, in most of the larger stream bottoms of Madison, about 3 miles southwest of Greensboro in Henry, at Connor's Mill of Hamilton, in Big and Little Flatrock creeks of southern Rush, in southwestern Fayette, 2 miles west of Laurel, and on the bluffs above Brookville in Franklin County. The latter is found in the larger streams of southern Wayne, those west of Connersville in Fayette, the larger tributary stream bottoms to East Fork of White River of Union, and in almost all of the larger tributary streams to White River and its East and West Forks in Franklin County.

Both of these stones are being used for macadam, but the Niagara is the more important, especially the hard, light buff dolomite, which occurs so frequently in Randolph, Delaware and Madison counties. The Cincinnati, because of its softness, is less durable.

The availability, as in the case of the gravel, is determined by the stripping, the amount of material, the amount of waste material and the transportation. The most available deposits occur near the surface by the streams, as the stripping generally increases rapidly as they get farther away. In determining the amount the stripping should be carefully examined. Furthermore, before going to too much expense to get the rock out, some preliminary examinations should be made in the area where operations are intended to be carried on, to learn the amount of waste and variations in quality. This can be done with a core drill, which will show the exact character. The steam railway and traction transportation where road material is gotten out on a very large scale is of very great importance; and in no part of the State are there better provisions than those in this area, with the exception of Fayette, Union and Franklin counties. At scarcely any point, with this exception, would material have to be hauled in wagons over 4 or 5 miles.

Besides the large stationary macadam plants, where two or three hundred cubic yards of limestone are crushed daily, there are small portable crushers that can be moved from place to place

with little expense. These are especially useful where an outcrop of stone is a considerable distance from transportation and the roads of the vicinity are in need of improvement. With such a crusher 10 men can turn out from 40 to 60 cubic yards per day at a cost of from 50 to 70 cents per cubic yard.

RANDOLPH COUNTY.

Area in square miles	450
Population in 1900	28,653
Miles of public roads	900
Miles of improved roads	300
Percentage of roads improved	33.3
Miles improved with gravel	300
Miles improved with crushed stone	None
Original cost of gravel roads per mile	$1,500
Total original cost of improved roads	$450,000
Annual cost of repairs on gravel roads 5 years old	$75
First improved roads built	1862
Proportion of improved roads built since 1895 (per cent.)	5
Satisfaction of farmers with investment in improved roads	Good
Authority	Jno. H. Boltz, County Auditor

Randolph County is located on the eastern boundary of the State, and is bounded on the north by Jay, on the west by Delaware and Henry, on the south by Henry and Wayne, and on the east by the State of Ohio.

The geological epochs represented in the formations of this county are the Niagara limestone of the Silurian and the Wisconsin drift of the Pleistocene. The Niagara outcrops at various points along the Mississinewa and White rivers. The drift forms a heavy covering over the entire county, which presents itself, entirely across the southern portion, as a terminal moraine. It is this moraine that forms the principal watershed and the divide between White and Whitewater rivers. In it, on the "Summit," between Green's Fork and Martindale Creek and the Peoria division of the Big Four, is an altitude of 1,234.4 feet, which is the greatest measured in the State. Hills south of this point are estimated to be 50 feet higher, so 1,284.4 is probably the maximum altitude of Indiana.

The transportation facilities are of the best. Two divisions of the Big Four cross it from east and west, one through the center

and the other across the southern third. The G. R. & I. bisects it from north and south, and the P., C. & St. L. crosses the northwestern quarter. The C., C. & L. crosses the southwestern corner.

The quality of the gravel of this county is below the average for

RANDOLPH COUNTY.

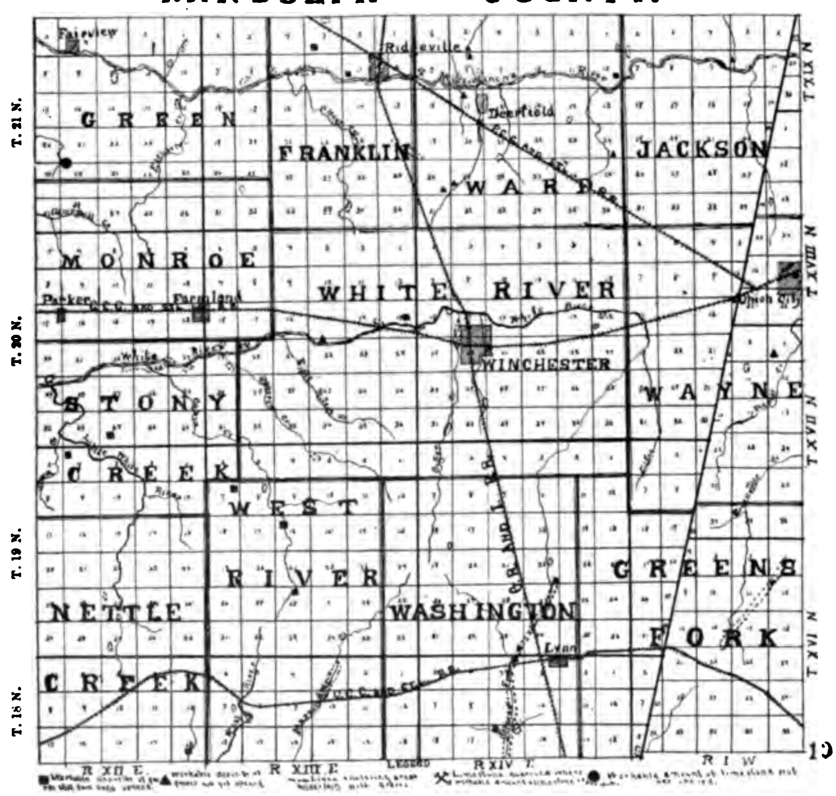

Fig. 28. Map of Randolph County, showing distribution of road materials.

central Indiana. The average sizes of material are 11 per cent. clay, 20 per cent. fine medium sand, 18 per cent. medium sand, 20 per cent. coarse sand, 21 per cent. roofing pebble, 9 per cent. gravel and 1 per cent. boulder; and the average rock percentages are 86 limestone, 9 crystallines, 2 shale, 2 chert and 1 slate. The amount of oxidation is above the average.

Township 21 North, Ranges 13, 14, 15 and Part of 12 East; Southern Half of Township 19 and the Northern Half of 18 North, Range 1 West.

This area of 132 square miles comprises the northern portion of the county. In it the gravel deposits are for the most part fluvial, and are located in the flood plain, terraces and bluffs of the Mississinewa River and its tributaries; but besides these some very fair glacial deposits are found in kames which are in no way connected with the stream.

In the central part of section 10 (21 N., 12 E.), on the land owned by W. B. Foutz, are two locations. The one, which underlies about 10 acres and has a depth of 6 to 7 feet, is located above ground-water level in the flood plains of the Mississinewa River; the other, with about similar dimensions, lies above ground-water level 350 yards south. The stripping over both of these deposits ranges from 2½ to 4 feet.

In quality the two locations are about the same. Probably two-thirds of the material is from a fine to a fine medium sand, and the remainder is as follows: 6 per cent. clay, 25 per cent. fine medium sand, 20 per cent. medium sand, 30 per cent. coarse sand, 14 per cent. roofing pebble and 5 per cent. gravel. The fine to a medium sand and the road material are so closely associated that it is a difficult task to separate them. This fineness, in addition to their being rather thoroughly oxidized, gives a rather inferior road metal. On the other hand, it is the only known workable deposit of gravel within reasonable hauling distance of the western portion of the county. The writer is of the opinion that in this vicinity crushed limestone would be more available than gravel, since the Niagara at a number of points is very near the surface. A crushed limestone base and a gravel dressing would be a very good combination, which, because of its durability, would be cheaper than the gravel alone.

Two miles southeast of the Foutz location, on the Henry McVey farm, in section 13 (21 N., 12 E.), is a deposit above ground-water level in the bluff on the west side of Elkhorn Creek. It underlies about 2 acres, is, where tested, 16 feet deep and has from 2½ to 4 feet of stripping. The physical properties of this material are about the same as the Foutz.

Small deposits, where there is considerable clay and sand to contend with, are located in the northwestern quarter of section 12, on the Samuel Uphaus land, and in the southeastern quarter of section 1 (21 N., 12 E.), on the J. Caylor farm. This material is fine and much oxidized, and is suited for only light local repair work.

On the place of H. Ingle, in the southwestern quarter of section 8 (21 N., 13 E.), is a bed of gravel and sand in the flood plain of the Mississinewa River. This bed is known to underlie 3 or 4 acres, with a depth of 4 feet above ground-water level and an unknown depth below, and has a stripping of from 2 to 4 feet. In character the material is probably two-thirds fine sand, fine medium sand and clay. The workable portions are about the average for size and rock composition. The colors, brown above and gray below ground-water level, are due to the weathering and absence of weathering.

This gravel has not been used to any great extent on account of such a small amount being above ground-water level. No tests have been made for setting a *dipping machine. If a location can be obtained for dipping or chaining it will be a very practicable one, because there are no gravel deposits west in the township.

In the southwestern portion of section 29 (21 N., 13 E.), on the M. Zimmerman land, a bed composed of gravel and sand is situated in a plain, and seems to have no connection with the stream channels. It extends over several acres, has a depth of from 5 to 7 feet and a stripping varying between 3 and 6 feet.

Because of the high percentage of sand and the difficulty in separating it from the gravel this is a subordinate road material. The average of two samples shows the following sizes: 5 per cent. clay, 50 per cent. fine medium sand, 16 per cent. medium sand, 16 per cent. coarse sand, 10 per cent. roofing pebble and 3 per cent. gravel. The rock percentages are 85 limestone, 11 crystallines, 1 chert, 1 slate and 2 shale.

Six hundred cubic yards from this deposit are used annually in building and repairing the roads for 5 miles west, 2 miles south, 1 mile east and ¼ mile north. All of these roads are more

*For a description of the dipping and chaining processes see page 324.

or less sandy, and are less durable than the average of the county because of the amount of oxidation and the fineness of the material.

On the J. McHenry farm, in the northwestern quarter of section 9 (21 N., 13 E.), there is a bed of gravel from 4 to 6 feet, above the ground-water level, and with an unknown depth below. The amount of surface underlain is unknown, and the stripping is from 2 to 3 feet. In quality this material is similar to that of the H. Ingle farm heretofore mentioned.

In the east-central part of section 9 (21 N., 13 E.), on J. R. Miller's place, is probably ½ acre underlain by 9 feet of gravel, with 1½ foot of stripping. On the same farm, but about 300 yards east, is a bank pit in the bluff of the river. This bed of sand and gravel underlies about two acres, which are cut into by the wagon road. The depth is 9 feet and the stripping is 1½ feet. Another location on this farm is found in the southwestern part of section 10 about 300 yards due south of the one last described. By using all three of these deposits one would be able to get a workable amount of gravel.

The quality of these materials is very much alike in rock composition. In size the first deposit mentioned is no more than medium sand; the rock percentages of the second deposit are about the average. The third location has 10 per cent. clay, 20 per cent. fine medium sand, 25 per cent. medium sand, 30 per cent. coarse sand and 15 per cent. roofing pebble. The color of these materials is brown; and the oxidation of the finer material is almost complete in places, while that of the coarsest is merely a thin film on the surfaces. Some of this material is used on the wagon roads as far as 3 miles west, 1½ miles east and 1 mile south. It seems to be about an average for the county in wear.

On the place of J. M. Hollowell, in the southwestern part of section 3 (21 N., 13 E.), is a bed of gravel, above ground-water level, in the first terrace above the flood plain. The deposit, which rests upon a clay bottom, underlies 6 acres, has a depth of 6 feet and a stripping ranging from 2 to 3 feet. The extent has been determined by post auger holes, groundhog excavations and the fact that corn over this piece of ground will die if the weather is dry, while the remainder of the crop seems to be little affected.

The quality of this gravel is good for a bank deposit. The size, which is above the average, is 6 per cent. clay, 6 per cent. fine medium sand, 8 per cent. medium sand, 27 per cent. coarse sand, 31.5 per cent. roofing pebble, 20 per cent. gravel and 1.5 per cent. boulder. Small lenses of sand occur frequently, and in places the gravel gives away entirely to a fine medium sand which is used for concrete work. The rock composition is the average for the county. Because of the coarseness, the oxidation has been very little. About 2,000 cubic yards of this material is put on to the roads annually, being hauled as far as 7 miles to the north, but very little in other directions.

On the L. D. Platt land, in the northeastern quarter of section 3 (21 N., 13 E.), the gravel occurs in a glacial kame. The areal extent, which is 50 by 150 yards, is determined by two pits, which are on either side of the kame, have similar materials, and are 150 yards apart. The depth of the bed is 12 feet, and the stripping is 3 feet.

The peculiar phenomena of this deposit is its absence of stratification, and the confusedly commingling of clay, sand and gravel. Irregular masses of clay or sand, 7 or 8 feet through, are frequently met with in the gravel. The average size of the material as seen in two samples is as follows: 10 per cent clay, 8 per cent. fine medium sand, 7 per cent. medium sand, 18 per cent. coarse sand, 25 per cent. roofing pebble, 30 per cent. gravel, and 2 per cent. boulder. The rock percentages are 85 limestone, 11 crystallines, 1 slate, 1 chert, and 2 shale. The coarseness, and limited amount of oxidation makes this above the average of the county as a wearing material, from above the ground-water level.

The availability is affected somewhat by the irregular masses of clay and sand, which have to be worked around, in obtaining the gravel. The location has a greater altitude than the road, and is only about 250 yards from it. This deposit is used but very little in repairing or building roads in Randolph County.

On John Caylor's farm, in the southwestern part of section 11 (21 N., 13 E.), a bed of sand and gravel is found in the lower terrace of the Mississinewa River. By tests, it has been found to underlie an area 50 by 250 yards, has a depth ranging between

8 and 12 feet, above ground-water level, and has from 2 to 5 feet of stripping.

As to physical properties for wearing on the road, this material is somewhat above the average, which comes from above ground-water level. In kinds of rocks 85 per cent. are limestone, 11 per cent. crystallines, 1 per cent. slate, 1 per cent. chert, and 2 per cent. shale. The sizes are 10 per cent. clay, 15 per cent. fine medium sand, 10 per cent. medium sand, 20 per cent. coarse sand, 30 per cent. roofing pebble, and 15 per cent. gravel. The roads, on which this material has been used, are hard, smooth, and durable. Although in places the gravel grades into sand, and clay, yet the quantity is not great enough to greatly affect the availability.

At the southwestern corner of Ridgeville, in the south bluff of the Mississinewa River, and on the E. Hyatt lots, is a bed of gravel and sand known to be 100 yards long, 20 yards wide, and from 8 to 12 feet deep. This gravel is too fine for a good road metal, and is used, for the most part, in concrete work at Ridgeville.

On the east bank of Bear Creek, in the north-central portion of section 23 (21 N., 13 E.), is a deposit of gravel, sand, and clay on the James Addington place. The lateral extent is not determined, but the depth is 15 feet, and the bottom is clay. The quality of this gravel is somewhat affected by the high percentages of clay, sometimes becoming as much as 75 per cent. The size, with exception of the clay and a rather high per cent. of boulders, is very good for road building. A sample shows 17 per cent. clay, 5 per cent. fine medium sand, 10 per cent. medium sand, 10 per cent. coarse sand, 35 per cent. roofing pebble, 18 per cent. gravel and 5 per cent. boulder.

Along the bluffs of the Mississinewa River, in the northwestern part of section 17 (21 N., 14 E.), on the A. Reitenour and D. H. Reitenour places, are deposits which underlie 15,000 square yards. On the former's place, which is adjacent to the latter's, about 13,000 square yards have been tested by a post auger, excavations for a cellar and well, and a cistern, which is in 10 feet of gravel. One hundred yards north of the cistern, the walls of the pit show 10 feet of gravel, and from 2 to 4 feet of stripping. The latter's

farm has been tested over 2,000 square yards, by various excavations, where the house and barn now stand. A cemetery, which is between these two locations, shows a fair quality of gravel at the bottoms of the graves.

The average size is 2 per cent. of clay, 13 per cent. fine medium sand, 13 per cent. medium sand, 28 per cent. coarse sand, 33 per cent. roofing pebble, 10 per cent. gravel, and 1 per cent. boulder. Because of the low percentage of clay, this gravel is slow to pack. This permits it to work off at the sides of the road, thus requiring much grading to keep the roads in order. If it remains on the road, its loose condition permits it to grind much more than if it were cemented. On the other hand, the material is coarser than the average, and consequently is not much oxidized. This brings the durability up to the average gravel. This material is used on the roads for 2 miles north, 2 miles east, 2 miles south, and 1 mile west.

In a flood plain of the southeastern quarter of section 5 (21 N., 14 E.), on the land of A. I. Collins, is a deposit of gravel that extends south through the Minerva Pierce farm of the southeastern quarter of section 8 to the Mississinewa River. This extent has been learned by the excavation of a ditch, which showed gravel in its bottom throughout this entire distance. The width of the deposit on the Collins place is 30 yards, the depth 14½ feet, and the stripping from 2½ to 5 feet. The rock percentages are 86 limestone, 10 crystallines, 1 slate, 2 shale, and 1 chert. The average size is 9 per cent. clay, 18 per cent. fine medium sand, 15 per cent. medium sand, 30 per cent. coarse sand, 20 per cent. roofing pebble, 7 per cent. gravel, and 1 per cent. boulder. The oxidation, above ground-water level, is slight, and below, nothing. This gravel is hauled, for road repairing, 3 miles north, 3 miles east, and 1 mile west. The selling price, for the bank gravel, is 25 cents per cubic yard, and that of the dipped is 50 cents. The dipped is claimed to be, because of its less weathered condition, and its greater durability, the cheaper gravel, especially for those who haul more than a mile.

A kame deposit, which rises 30 feet above the adjacent country, in the southeastern quarter of section 30 (21 N., 14 E.), on the farm of T. H. Clark, underlies an area of 2 acres. Dug wells, cellars, and other excavations show the bed to be within 1½ to

4 feet of the surface, and to have a depth varying between 12 and 23 feet. The quality of this gravel is similar to that on the Mullen farm, the discussion of which is commenced in the next paragraph.

Also in kames, which rise decidedly above the immediate vicinity, are the beds of gravel on the Mullen land, in the southwestern quarter of section 29 (21 N., 14 E.). The house and barn sit on one kame, which has an area of 1½ acres, a stripping of 2 feet and a depth of 8 feet, as shown by various excavations. South of the house, a couple of hundred yards, is another kame, which has an area of 2 acres. The writer dug into this kame at several places, on various sides of it, and found that it contained a medium sized gravel within about 2 feet of the surface. Another kame on this farm has been opened for some years, and is now almost exhausted. Because of the fineness, and the amount of oxidation, the quality is below the average for the county. The roads built by it soon become rutty. The rock composition is about average. This deposit and the one on the Clark farm are the only ones which are available in this neighborhood. There is no known deposit nearer than 3½ miles south, 5 miles east, and 3 miles west.

Another kame deposit is found on the land of Samuel Grew in the west-central portion of section 14 (21 N., 14 E.). Here, about 2 acres are said to be underlain with gravel, which is beneath 5 feet of stripping. The depth of this deposit is about 10 feet. The quality is poor, on account of the numerous irregular masses of clay. The average sizes are 10 per cent. clay, 20 per cent. fine medium sand, 10 per cent. medium sand, 45 per cent. coarse sand, 10 per cent. roofing pebble and 5 per cent. gravel. The fineness of this material has permitted considerable weathering. This gravel is used 1½ miles north, 1 mile east, and 1 mile south. The roads repaired with it are muddy and dusty.

On the B. V. M. Brouse property, in the southwestern part of section 21 (21 N., 14 E.), is a small deposit of exceptionally good gravel. It underlies about 500 square yards, is from 1½ to 3 feet beneath the surface, and is 5 feet deep. The rock composition and size are about the average. The oxidation is practically nothing.

In the flood plains of a small stream in the southeastern quarter of section 24 (21 N., 13 E.), on the Hall Bros. farm, is a bed of gravel beneath the ground-water level. The water, by pumping, was readily exhausted so that the gravel was taken out to a depth of 10 feet below the ground-water level. Such an exhaustion could not have taken place unless some impervious material, such as clay, encased the deposit. Although this same kind of material is found, in the same flood plains, 500 yards southeast on the Heston farm, in the southwestern quarter of section 19 (21 N., 14 E.), yet this is no evidence that the bed is continuous for the 500 yards. It rather appears, because of the rapid exhaustion of the water, that the gravel is in pockets, and that these are small. Very careful testing should be done, by driving pipes or in some other way, before a machine of any kind is set for lifting the material out. The quality of this material is reported as being a medium gray gravel, which packs quickly.

On the land of S. Shaw, in the southeastern quarter of section 12 (21 N., 14 E.), in the flood plains of the Mississinewa River, is a small area, which is underlain with about 12 feet of gravel, 7 feet being below ground-water level and 5 feet above. The stripping is from 4 to 10 feet. The quality of the material is rather fine for road building, being 5 per cent. clay, 25 per cent. fine medium sand, 50 per cent. medium sand, 10 per cent. coarse sand, and 10 per cent. roofing pebble.

In the southwestern quarter of section 24 (21 N., 14 E.), in a flood plain on the Rollie Warren land, 5 or 6 acres are known to be more or less underlain by gravel and to have from 2 to 3 feet of stripping. The depth at the pit is 20 feet beneath ground-water level. The gravel has been taken out to a depth of 10 feet, after first pumping out the water. The fact that the water can be pumped out shows that the deposit must be in a pocket in the clay, and that testing is very essential before setting a machine. If considerable clay is present, the endless chain process would probably give the best satisfaction in lifting the material. This material is unoxidized, and is of an average size and rock composition.

Two thousand cubic yards of this material are put on the roads annually, at from 45 to 70 cents per cubic yard. It is hauled 6 miles west, 4 miles north, 7 miles east, and 4 miles south.

On the Porter place, in the southwestern portion of section 6 (21 N., 15 E.), a bed of gravel, with from 0 to 2½ feet of stripping, underlies about 4,000 square yards in a hill. In one part of it, where a test has been made, the depth is 18 feet. The sizes of this gravel are 10 per cent. clay, 10 per cent. fine medium sand, 65 per cent. coarse sand, 14 per cent. roofing pebble, and 1 per cent. boulder. The color is brown, and the oxidation about the average for a bank deposit in this county.

Workable deposits are found in the ground moraine, on the E. M. Clough farm, of the northeastern corner of section 9, and the northwestern corner of section 10 (21 N., 15 E.). In the latter location, tests indicate that, under from 3 to 5 feet of stripping, 20 acres are underlain by gravel, which ranges in depth between 3 and 10 feet, 4 feet being above and from 3 to 6 feet below ground-water level. The quality, as to size, is 10 per cent. clay, 20 per cent. fine medium sand, 15 per cent. medium sand, 35 per cent. coarse sand, and 20 per cent. roofing pebble. This is not very good for road building. The oxidization, with exception of very near the surface, is not great. This material is used in repair work and building, for 1 mile north, 4 miles east, 4 miles south, and 1½ miles west.

Township 20 North, Ranges 13, 14, 15 East, and Parts of Townships 18 and 17 North, Range 1 West.

The geographical and topographical location of the gravel in this 132 square miles are especially interesting. The entire area is covered by a heavy deposit of glacial moraine, which is made up mainly of clay, a smaller amount of sand, and a still smaller amount of gravel, which is so intermingled with the clay and sand that some concentration is necessary before it is of any economic importance. North of the White River, no noticeable concentration has taken place. Not a single workable deposit is found in this entire area, which composes more than half of the 132 square miles. The main deposits are found along White River, but there are some fair ones in the flood plains of a few of its tributaries, and also where there appears to have been no stream concentration. The reason for this peculiar phenomena is very evident.

North of White River, from 1/4 to 2 miles, is a water shed, through which the tributaries of the Mississinewa and those of the White River have failed to work their heads. In this water shed, fluvial concentrations have scarcely taken place, and for a couple of miles north and south to the White River the sources of the tributaries are so small that they have collected only very small deposits.

South of White River, the tributaries are much larger than those north, and have numerous smaller tributaries themselves, which form a sort of net work over this region that picks up the gravel, sand and clay of the ground moraine, and deposits them as homogeneous materials, thus bringing about the separation and concentration. Another advantage the streams south of White River have over those north, is that they pass through a heavier moraine, which naturally contains a coarser gravel. One mile west of Unionport, the topography is hummocky, and contains some kettle holes.

In some low hills, on the G. O. Thompson land of the northeastern quarter of section 29 (20 N., 12 E.), is a total area of about 16,000 square yards underlain by gravel, with more or less sand and clay. The depth is from 5 to 12 feet, and the amount of stripping is from 1½ to 4 feet. The tests giving this data have come from post auger holes and pit openings in a very general way. Before working this deposit, the writer would suggest that an iron pipe test be tried, so that the quality and amount of the gravel may be determined.

The following physical characteristics are to be noted: The rocks are 86 per cent. limestone, 11 per cent. crystallines, 1 per cent. shale, 1 per cent. slate, and 1 per cent. chert. The average sizes of two samples are 9 per cent. clay, 11 per cent. fine medium sand, 13 per cent. medium sand, 25 per cent. coarse sand, 15 per cent. roofing pebble, 24 per cent. gravel and 3 per cent. boulder. The oxidation has affected the deposit about the average amount for one above ground-water level, and has given it a brown color. The clay contains some lime, which serves as a cement. Each year from 1,500 to 2,500 cubic yards of this material are used in repairing the roads for 5 miles west, 1 mile south and 3½ miles east.

Forty feet above the adjacent region, in a large hill on the Samuel Amburn and Gates farms of section 34 (20 N., 12 E.), is a gravel deposit, grading more or less into clay and sand, which will underlie 8 or 9 acres, with an average depth of 25 feet. This extent and depth has been determined by several pit openings.

In percentages of rocks, 85 per cent. is limestone, 11 per cent crystallines, 2 per cent. shale, 1 per cent. chert, and 1 per cent. slate. The exposure on a pit wall showed:

Section of Gravel at the Amburn Pit.

	Feet.	Inches.
1. Stripping	3	..
2. Coarse brown gravel	15	..
3. Fine medium sand	5	..
4. Medium light brown gravel	15	..

The average of two samples are 10 per cent. clay, 7 per cent. fine medium sand, 15 per cent medium sand, 18 per cent. coarse sand, 15 per cent. roofing pebble, 33 per cent. gravel and 2 per cent. boulder. The amount of oxidation is about an average for a deposit above ground-water level, in Randolph County. About 1,500 cubic yards of this gravel are used annually in repair work.

On the farm of George Thornburg, in the southeastern quarter of section 22 (20 N., 12 E.), is a deposit extending for 200 yards along the south bluff of White River. Tests have also shown its extent back from the face of the bluff to be 15 yards and its depth to be 8 feet. There are from 2 to 5 feet of stripping. A sample of material from this location shows 8 per cent. clay, 20 per cent. fine medium sand, 15 per cent. medium sand, 25 per cent. coarse sand, 16 per cent. roofing pebble, 15 per cent. gravel, and 1 per cent. boulder. The rock composition and oxidation are about the same as in the *Thompson deposit.

About 1/4 of a mile east of the Thornburg location and in the bluff of a tributary to White River is a gravel bed on the J. D. Wright land, of the southwestern quarter of section 23 (20 N., 12 E.). It has a length of 100 yards and a depth of 8 to 9 feet, but the width has not been determined. The stripping is from 2 to 4 feet. The quality of this gravel is about the same as the

*See page 338

Thornburg. About 800 cubic yards of this material are used annually in repairing roads 1 mile north, 1 mile south and 2 miles east.

In the northeastern quarter of section 23 (20 N., 12 E.), on the J. Driver place, is a bed of gravel, which is known to underlie 12 or 13 acres of the flood plain of White River. Tests have shown the depth to vary from 1 to 10 feet.

On the land of W. Wright, which is just across the road from the Driver deposit, is a small pit, which shows a depth of 7 feet, and from 2 to 4 feet of stripping. The quality of this gravel is about the average. The oxidation is low, because a considerable per cent. is either below ground-water level or has been in recent geological times. About 1,500 cubic yards is used annually in repairing roads as far as 4 miles east and 2 miles south. The gravel, because of a fair amount of calcareous clay, packs well and makes a hard and smooth road.

On the R. T. Mills farm, in the southeast quarter of section 19 (20 N., 13 E.), is a location at the top of a hill which has a quaquaversal slope. The deposit, as known, underlies about 6,000 square yards and is, in a couple of places where it has been tested by driving down a pipe, 10 yards deep. The quality of this gravel is extraordinarily good. At a depth of 10 feet, the weathering is very slight, and the color is almost a gray. The size is 5 per cent. clay, 5 per cent. fine medium sand, 15 per cent medium sand, 30 per cent. coarse sand, 35 per cent. roofing pebble, 9 per cent. gravel and 1 per cent. boulder. Rock percentages are 84 limestone, 12 crystallines, 1 slate, 1 chert, and 2 shale. The clay is of a very calcareous nature, and cements the material together when it is put onto the road. Annually, 1,000 cubic yards of this material are put on the roads to a distance of 1½ miles north, ½ mile west, and 1 mile south.

A bank deposit, in and back from the bluffs of White River and on the land owned by E. E. Franklin in the northwestern quarter of section 22 (20 N., 13 E.), has an extent of 100 by 200 yards. This extent was determined from the gravel pit and three test pits, which were each 10 feet deep. The stripping varies from 2 to 3 feet, and the depth of gravel from 7 to 8 feet. Frequently the gravel grades into sand, so that it will not be certain

without more tests that the area between the test pits is underlain by gravel.

The quality of this gravel is below the average of this county, because of its fineness and high amount of oxidation. The rock percentages are about average. One thousand cubic yards of this gravel, at a rate of 35 cents per cubic yard, are put on the roads annually for repair work.

In the southeastern corner of section 14 (20 N., 13 E.), on the C. E. Magee place, the deposit is on a slope which extends down to the bluffs of White River. No pit has been opened here, but two tests have been made at points 150 yards apart; one of these tests was a pit 8 feet deep and 4 feet in diameter, which showed 2 feet of stripping, 6 feet of gravel, and no bottom; the other test was a boring of 11 feet, which gave 2 feet of stripping, 9 feet of gravel, and no bottom. The quality of the gravel is in size and rock composition about average. The color is brown, which is due to oxidation. As in most bank pits of this county, the oxidation has not affected greatly the material from a roofing pebble on up.

On the J. H. Thornburg farm, in the southeastern quarter of section 13 (20 N., 13 E.), the gravel bed is in the bluffs of a tributary of White River, and has a surface extent of 10 or 11 acres. The depth is about 15 feet, and the stripping from 1½ to 2½ feet. These facts have been determined by a number of test pits 8 feet deep and 6 or 7 feet in diameter. As to its character as a road material, it is oxidized about the same as the Magee deposit. The average sizes for two samples are 15 per cent. clay, 34 per cent. fine medium sand, 9 per cent. medium sand, 17 per cent. coarse sand, 10 per cent. roofing pebble, 14 per cent. gravel, and 1 per cent. boulder. The rock percentages are about the average.

The location of the Herman Murphy place, which is in the southeastern corner of section 13 (20 N., 13 E.), is found in the bluff of White River, underlying, more or less, some 6 acres of surface which has been tested by test pits and post auger holes. The general depth is unknown, but at the pit it is 15 feet, with 2 to 4 feet of stripping. As to whether this deposit is workable is a difficult question, because of the abrupt changes from gravel to sand. Fully half of the material in the pit is sand.

As to quality, the oxidation is average for a bank deposit of the county. The rock percentages are 89 limestone, 7 crystallines, 2 shale, 1 slate and 1 chert. The average of three samples shows the following sizes: 10 per cent. clay, 30 per cent. fine medium sand, 12 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 7 per cent. gravel, and 1 per cent. boulder. The clay of this gravel is very calcareous and makes a good cement for packing, hardening, and holding the material in place in the road. This gravel is used in repair work for 2 miles west, 1 mile south, and 1 mile east. It is most too fine for building a road.

The Pogue pit is just across the road from the Murphy, and is also located in the bluff of White River. Although there are several acres underlain by gravel and sand, the fine medium sand is so predominant that the deposit is impracticable for a road material.

The location on the farm of John H. Lee, in the southeastern part of section 27 (20 N., 13 E.), is found in the bluff, above ground-water level, and in the flood plains, below ground-water level, of Eight Mile Creek. The bank deposit, although it underlies several acres, has to such a great extent graded into sand that it is impracticable except for very local repair work. The flood plain deposit also covers several acres, but is only from 2 to 5 feet deep, and is beneath from 2 to 5 feet of stripping.

In the southeast quarter of section 18 (20 N., 14 E.), on the A. Slusher land, is a deposit in the bluff of White River which by test is known to underlie 3 acres. An exposure shows the following:

Section at A. Slusher's Gravel Pit.

	Feet.	Inches.
1. Stripping	3	..
2. Yellowish brown gravel, considerably oxidized	2	..
3. Clay, sand, and coarse gravel about equally mixed	2	..
4. A light brown gravel, not much oxidized	6	..
5. Sand	..	..

The rock composition is about the average for the county. Because of the fact that the deposit is 3/4 sand, it can scarcely be termed workable. The gravel in general is too fine for anything more than very light repair work.

In the southeastern part of section 31 (20 N., 14 E.), on the M. A. Wright farm, is a bed of gravel located in the flood plain of Sugar Creek beneath the ground-water level. About 5,000 square yards are known, by pipe driving, to be underlain by gravel, with a depth of from 15 to 21 feet. The stripping is from 2 to 4 feet. The quality, as to size, is 14 per cent. clay, 10 per cent. fine-medium sand, 5 per cent. medium sand, 13 per cent. coarse sand, 25 per cent. roofing pebble, 30 per cent. gravel, and 3 per cent. boulder; as to rocks, 88 per cent. are limestone, 2 per cent. shale, 8 per cent. crystallines, 1 per cent. slate, and 1 per cent. chert. It is unoxidized, and has a gray color. The clay is rather calcareous, and serves as a cement.

It is very probable that other workable deposits can be found at other points along Sugar Creek. Tests have already indicated pockets a few hundred yards further down stream, but they are too small for setting a gravel excavator or they contain too much clay. It is possible that the endless chain process could be used where there is too much clay for *dipping.

The County Farm deposits, in the southwestern corner of section 33 (20 N., 14 E.), cover an area, as has been learned by tests, of 100 by 40 yards, and is 5 yards deep. Beyond these limits the gravel contains lenses of clay, which make it impracticable for dipping; but the endless chain process might work.

The quality of this material, as is seen from the average of two samples, is 12 per cent. clay, 23 per cent. fine medium sand, 10 per cent. medium sand, 22 per cent. coarse sand, 20 per cent. roofing pebble, 12 per cent. gravel and 1 per cent. boulder. The rock percentages are 85 limestone, 6 shale, 6 crystallines, 2 chert, and 1 slate. Oxidation is practically nothing. The clay is somewhat calcareous and serves as a very fair cement. This material is used for 5 miles east, 2 miles north, 4 miles south, and ½ mile west. Where it has been used in repairing it seems to pack quickly, and makes a smooth, hard and durable road.

In the northwestern part of Winchester near the old fair ground, 10 or 11 acres are underlain by a deposit of gravel, sand, and clay, in the flood plain of Sugar Creek. This area has been well tested, and in almost all cases, too much clay is found to pay for setting a machine for dipping. The endless chain process

*See page 324.

might work here, since it allows considerable of the clay and dirt to be washed out. The gravel, which has been taken out, is made up of 15 per cent. clay, 10 per cent. fine medium sand, 10 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 21 per cent. gravel, and 4 per cent. boulder. The percentages of rocks are about the average.

In the northwestern quarter of section 13 (20 N., 14 E.), on the S. Clevinger land, is a deposit in the flood plain and bed of White River, that is 250 yards long, 25 yards wide, and from 6 to 9 feet deep. The stripping is from 2½ to 4 feet. The rock percentages and sizes of the material are about the average for the county, and the amount of weathering is very small. In this vicinity, this is about the only available gravel. Eight hundred cubic yards, at 40 cents per cubic yard, are used annually in repairing and building roads. It is hauled, for road purposes, 4 miles north, 3½ miles east, 2½ miles south and 2 miles west.

East of White River, there is only one known workable deposit, and that is on the place of R. Dickson, in the southwestern corner of section 1 (17 N., 15 E.). This gravel bed is in a low knoll of the ground moraine and underlies 12 or 13 acres. Under from 2 to 5 feet of stripping, a depth, of from 3 to 6 feet above ground-water level, is found. The quality, as is shown by rock percentages, is 84 limestone, 12 crystallines, 1 chert, 1 slate, and 2 shale. The sizes, on an average, are 20 per cent. clay and 80 per cent. roofing pebble. Oxidization is low in the gravel above the ground-water level and is nothing in that below. On account of the high percentage of clay, roads become dusty in the summer and somewhat muddy in the winter, but they are generally smooth, hard, and durable.

Without a doubt a large quantity can be gotten from beneath the water. This gravel, because of its unweathered condition, will be found to be more durable than that which is being put on the road at present. Although for setting a dipping machine to obtain the gravel beneath the water level no tests have been made, yet it is probable that the percentage of clay is too high, and that the endless chain would give better satisfaction. Before setting any machine, very careful testing will be necessary. This gravel is used for 2½ miles south, 1 mile east, 3½ miles north, and 2

miles west. One thousand four hundred cubic yards of the bank gravel are sold annually at 35 cents per cubic yard.

Because of the high percentage of ungraveled and poorly graveled roads, and the limited amount of bank gravel in this vicinity, it will be but a brief time until some other source for road material will be necessary. In selecting this material, it will be very essential that the durability of various road metals be considered. Since limestone is more durable than gravel, the writer will refer the reader to the tests made at the Road Laboratory of the United States upon the limestone at *Ridgeville and in other neighboring counties.

In the southeastern quarter of section 31 (20 N., 15 E.), on the L. Chinaworth place, several acres, in the flood plain of a small stream, are underlain by a bed of gravel, sand and clay. The depth is from 2 to 7 feet, and the stripping is from 2 to 4 feet. Tests have been made for setting a dipping machine, but there is too much clay to contend with.

On the farm of W. Schultz, in the southeastern corner of section 19 (20 N., 15 E.), is a bed of gravel, sand, and clay beneath the ground-water level, in the flood plain of a small creek. A rather general testing shows that several acres are underlain by this deposit. Where taken out, it had a depth of 11 feet beneath 5 feet of stripping. The quality is inferior because of the high percentage of clay. Some of this could be avoided if the endless chain process would be used instead of the dipping machine. This gravel was sold for 40 cents a cubic yard and was used 2 miles north, 2 miles east, 1 mile south and 1 mile west.

The deposits on the R. Wilkerson place, in the northwestern quarter of section 11, are located in small surface raises which cover, all taken together, 5 or 6 acres, with a depth in one place, where a test was made, of 13 feet. The stripping is about 4 feet.

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*See page 157.

Township 19 North and the Northern Part of 18 North, Ranges 13, 14, 15, and Part of 12 East, and Parts of Townships 16 and 17 North, Range 1 West.

In this area of 198 square miles, the larger deposits are found in the flood plains of Green's Fork, in the bluffs of Cabin Creek, and in the hummocky moraine, 1 mile west of Unionport. All of the larger streams, such as Little White River, West River, Martindale Creek, White River, and Greenville Creek, contain deposits of economic value in their bluffs, terraces and flood plains; but on and near the divides, such as is found near the western border in the civil township of West River, the gravel has not been segregated by stream work and no deposits of economic importance are found.

In the civil township of Green's Fork, the deposit is found below ground-water level and along a northeast and southwest belt, which extends from the south-central part of section 15, 1¼ miles south of Spartanburg, northeast through the northwest part of section 14, across section 11, through the northwest part of section 12, and into the central part of section 1 (16 N., 1 W.). Through tests, by driving pipes, this belt has been found to be about 150 feet wide and from 1 to 20 feet in depth. At several places in this belt the tests have shown the gravel to be in sufficient quantities to pay for setting a dipping machine, which could not be set for less than 4 or 5 thousand cubic yards. This deposit is very available, having a stripping of from 2 to 7 feet, and being very accessible to the public highways.

In a general way, the quality of the gravel is above the average of Randolph County. The amount of oxidation is very little, since it is largely beneath the ground-water level. The rock composition, at various parts of the deposit, is seen to be as follows: In the south-central part of section 15 there is 83 per cent. of limestone, 10 per cent. crystallines, 2 per cent. chert, 4 per cent. shale, and 1 per cent. slate. In the northeastern part of section 12, on Clara Wood's place, in a bank pit, the writer found a material with an average rock composition. In the southeastern part of the northwestern quarter of section 1, on H. Alexander's farm, is a deposit beneath ground-water level, which has the following rock percentages: 83 limestone, 11 crystallines, 3 shale,

2 slate and 1 chert. The size of the gravel in section 15 (16 N., 1 W.) is 10 per cent. clay, 20 per cent. medium sand, 15 per cent. coarse sand, 45 per cent. roofing pebble, 9 per cent. gravel, and 1 per cent. boulder; on Clara Wood's farm, it is 10 per cent. clay, 30 per cent. sand, 48 per cent. roofing pebble, 11 per cent. gravel, and 1 per cent. boulder; on H. Alexander's farm it is 13 per cent. clay, 30 per cent. sand, 45 per cent. roofing pebble, 11 per cent. gravel and 1 per cent. boulder. The clay in all of thes deposits contains a small per cent. of lime, and is of a hard and tough nature, both of which tend to make it a good cementing material.

The only other deposit known of in this township, which is of any practical value, is located in the southeast quarter of section 18 (18 N., 15 E.). This, as far as is known, is a bank deposit, which has an extent of a couple of acres, a depth above ground-water level of 12 feet, and from 2½ to 5 feet of stripping. Since no bottom has been found other than water it is possible that some gravel could be obtained from beneath the water level. For this location I would recommend the *endless chain process, on account of the large amount of clay and dirt in the gravel.

In quality, this material is only fair. The color is brown, which is due to oxidation. In the smaller material, as from a flaxseed to a wheat grain, the oxidation has permeated the larger portion, where in the coarser material it only forms a small film. The percentages of the various rocks are as follows: 83 per cent. limestone, 10 per cent. crystallines, 2 per cent. chert, 1 per cent. slate, 4 per cent. shale. In size 15 per cent. is a somewhat calcareous clay, 15 per cent. fine medium sand, 15 per cent. medium sand, 20 per cent. coarse sand, 26 per cent. roofing pebble, 8 per cent. gravel, and 1 per cent. boulder. The oxidation, size and rock composition causes this gravel to pack well on the road, but not to wear as well as a coarser and less oxidized gravel. On an average, 1,100 cubic yards are put on the roads annually. This gravel is used in repair work and building as far as 4 miles east, 5 miles north, 2 miles west, and 1 mile south.

In Washington Township the workable deposits are found in the bed, flood plains, terraces and bluffs of Green's Fork. In the bed and flood plain, the deposits beneath the ground-water level

*See page 324.

have been tested by ditching and pipe driving from W. D. Daly's farm, section 22 (18 N., 14 E.), southwest across the farms of S. B. Clements, section 27, David Baxter's, northwestern quarter of section 34, Ezra Nye's, southeast quarter of section 33 (19 N., 14 E.); M. Anderson's, northeast quarter of section 4 (18 N., 14 E.); and onto the adjacent farm to the southwest. In the terraces and bluffs of Green's Fork the bank deposits have been tested on the farms of Amos Hodgin, southeast quarter of section 9, and L. E. Moody, northwest quarter of section 16, and the farm immediately south and across the road from the Amos Hodgin farm, northeast quarter of section 16 (18 N., 14 E.). Another deposit, above the ground-water level, is found on the F. Ritter farm, in the southeast quarter of section 18 (19 N., 14 E.).

The location on the Daly farm has been well tested by driving an iron pipe and by the dipping already done. The deposit that is still workable has an area of 3,000 square yards, with a width of 100 feet and a length of 300 feet or more, in the center of the Green's Fork valley. At the center of this deposit, the stripping is 1 foot, but at the sides it becomes 6 feet. Across the road on the Clement farm a good location has been found for setting a dipping machine, between the house and the road. For several hundred yards south to southwest of the house the gravel is found within a few feet of the surface, and wherever tested has a width of about 100 feet where the stripping does not become too heavy for working.

The gravel that has been dipped out on the Daly farm has an average rock composition. In size, 15 per cent. is clay, 25 per cent. fine medium sand, 9 per cent. medium sand, 26 per cent. coarse sand, 25 per cent. roofing pebble. The clay is somewhat calcareous and cements the material together when it is put on the road, thus making a hard and smooth bed. The color is a gray, which indicates the unweathered condition.

On the Clement farm the gravel is of about the same quality as on the Daly.

On the David Baxter farm, although the writer did not have the opportunity of seeing the gravel as it came from the pit, he learned from investigation that the quality was about the same as that of the Daly pit.

The location on the flood plain of Green's Fork, on the Ezra Nye and Anderson farms, which join each other, consists of a block 800 yards long, 150 yards wide, and from 4 to 7 yards deep, which is under from 1 to 7 feet of stripping. The limits of this location are determined by the increase in stripping, which is 1 foot at the center, 6 feet 60 yards from the center, and 8 feet 100 yards from it.

Average samples from the two farms have 86 per cent. limestone, 10 per cent. crystallines, 2 per cent. chert, 1 per cent. slate, and 1 per cent. shale. In size, 15 per cent. is clay, 18 per cent. fine medium sand, 13 per cent. medium sand, 25 per cent. coarse sand, 17 per cent. roofing pebble, 11 per cent. gravel, and 1 per cent. boulder. The clay is somewhat calcareous, and makes a good cementing substance. This gravel is used 4 miles east, 2 miles west, and 1 mile south in building and repairing the roads.

On the Amos Hodgin and L. E. Moody farms, and the farms in the northeast part of section 16, stratified gravel is found in the bluffs and terraces of Green's Fork and its tributaries. On the Amos Hodgin farm there are probably 2 acres underlain by a workable deposit, which has a depth ranging from 6 to 15 feet, and is under from 1 to 6 feet of stripping.

The rock is 86 per cent. limestone, 9 per cent. crystallines, 2 per cent. chert, 1 per cent. slate and 2 per cent. shale. The average of 6 samples show the following sizes: 4 per cent. clay, 21 per cent. fine medium sand, 23 per cent. medium sand, 17 per cent. coarse sand, 13 per cent. roofing pebble, 20 per cent. gravel and 2 per cent. boulder. A small per cent. of clay, low in lime, makes this a poor cementing gravel. It packs slowly and grinds to powder more readily than an average material. It is also oxidized and has a brown color.

Mr. Hodgin's gravel has been used in building 30 miles of road in this vicinity. It is hauled 6 miles east, 5 miles north, 2 miles west, and 1 mile south. The street leading to the depot in Lynn was built 9 years ago with the gravel and has had very little repair since. This street today is solid, smooth, and giving good satisfaction.

On the Moody farm, the gravel is known to underlie 4 or 5 acres, with from 1 to 6 feet of stripping. The depth in this bank

deposit is undetermined and tests, in the flood plains, have indicated that there is not a sufficient depth to warrant the setting of a machine for dipping. The rock composition is about the average. This gravel in quality is about the same as the Hodgin. It is used in building and repairing roads 4½ miles east, 2 miles west, and 1 mile north.

	Feet.	Inches.
1. Stripping	1 to 3	..
2. A brown gravel of medium size, considerably oxidized	16	..

The deposit on the F. Ritter farm is of very poor quality, and is only used locally. Although it underlies several acres and has a depth of 10 feet. The size of material is 50 per cent. clay, 10 per cent. fine medium sand, 8 per cent. medium sand, 13 per cent. coarse sand, 8 per cent. roofing pebble, 10 per cent. gravel, and 1 per cent. boulder. This high percentage of clay causes the roads on which it is used to be muddy in wet weather and dusty in dry.

In the flood plain of a branch of White River, on the property belonging to Restore Thornburg, 2 1-3 miles northwest of Bartonia, is an area of 2,000 square yards underlain with from 3 to 25 feet of gravel. Although tests have not yet given a location for dipping, on account of a high percentage of clay, yet it is very likely that the material could be obtained by the *endless chain method. The gravel, which has been taken out of this deposit, has been of a splendid quality. It was of a medium size, unoxidized, and contained a good cementing clay.

In West River Township, the workable deposits are found in the flood plains and bluffs of West River, Martindale and Cabin Creeks, and the moraine deposit 1 mile due west of Unionport.

On Martindale Creek, these deposits are located on the Bodkin farm, northeast quarter of section 3, and the Brown, southwestern quarter of section 3 (18 N., 13 E.). The deposit on the Bodkin, from the digging of a county ditch, is known to be 300 yards long. The width, where tested, is from 20 to 40 yards, depth from 6 to 10 feet, and the stripping is 3 feet. Two-thirds of the gravel lies beneath the ground-water level and is consequently in a very fresh condition.

*See page 324.

In size, 15 per cent. is clay, 14 per cent. fine-medium sand, 10 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 20 per cent. gravel, and 1 per cent. boulder. The clay is very calcareous, which causes the gravel to be quickly cemented together. It is claimed that this gravel will not spread out, as most gravel, when dumped on the road, but stops right where it is placed. The rock composition is 84 per cent. limestone, 11 per cent. crystallines, 1 per cent. chert, 1 per cent. slate, and 3 per cent. shale. This gravel is used north 5 miles, east 2 miles, west 2 miles, and south 2 miles. Because of its unoxidized condition and calcareous clay, it makes a very hard, smooth and durable road, and ranks as one of the best gravels of Randolph County. Because of the clay layers and lenses, and the limit of depth, the *endless chain process would probably be the most satisfactory for getting this material out.

On the Brown farm a similar quality of gravel to that on the Bodkin, is found, but the amount has not been determined. In a few places the depth is known to be more than 10 feet beneath the ground-water level.

On the Bodkin and Brown farms these fluvial deposits, as is seen from the stratified condition of the portion which is above the ground-water level, are pockets under the stream bed and flood plains. Undoubtedly a further investigation will show more deposits of a similar nature at other points along this same stream.

Other fluvial deposits, both above and below ground-water level, are found on the property of the Ritz heirs, southwest quarter of section 8, and that of Mr. Wright, southeast quarter of section 7 (18 N., 13 E.). On the Ritz farm several pits have been opened, but abandoned because of heavy stripping and inavailable amounts. The gravel beneath the ground-water level has never been carefully tested, but judging by the frequency of clay layers in the bank pits, it is likely that there would be too much of this material to contend with in dipping. The deposits, as known, occur in pockets, which contain from 500 to 3,000 cubic yards of available gravel.

Across West River, from the Ritz farm, is the Wright farm, from which gravel has been obtained for road purposes during a

*See page 324.

number of years. This deposit occurs as a bank. At present, because of inavailable amounts, the known deposit can not be termed workable, but by taking it together with the known deposits of the Ritz farm, a workable amount might be obtained.

All of the gravel beds that are of any economic importance along Cabin Creek are above the level of ground-water. They are found on the farms of C. Cougill, in the north-central part of section 38; William Clark, in the northwestern quarter of section 16, and Harry Pegg, in the north-central part of section 8 (19 N., 13 E.).

On the Cougill place, the deposit is in a hill which stands very conspicuously above the adjacent region. Thirty thousand square yards of its surface are underlain by this deposit, which is beneath from 2 to 7 feet of soil, and has a depth of from 5 to 35 feet. As a road material this is probably about an average for a bank deposit in this county. The following sizes were taken from the average of 5 samples: 8 per cent. clay, 13 per cent. fine medium sand, 30 per cent. medium sand, 19 per cent. coarse sand, 15 per cent. roofing pebble, 13 per cent. gravel, and 2 per cent. boulder. The rock percentages are about average. The brown color is due to oxidization, which has not noticeably affected the coarser material, but the finer is pretty well weathered through.

Three years ago and 3 miles east this material was used in building 3½ miles of road, which since has received $130.00 worth of repairs annually. It was also used 15 years ago in building 7 miles of road which runs east and west past the northern boundary of this deposit. This road, with some annual repairs, is still in a good condition. The part of the road which lies east of the portion graveled from this pit, and which was graveled at the same time from the Ritter pit, in the southeastern corner of section 18 (19 N., 14 E.), is very little better than a dirt road.

The Clark deposit underlies in the bluffs and flood plains an area of 75 by 250 yards. The depth in the bluff above ground-water level is from 15 to 20 feet, but in the flood plain has not been determined. The stripping is from 1 to 4 feet. As a road metal it is of an average character. The amounts of the various sizes are 8 per cent. clay, 15 per cent. fine medium sand, 10 per

cent. medium sand, 30 per cent. coarse sand, 20 per cent. roofing pebble, 15 per cent. gravel, and 2 per cent. boulder. The clay is somewhat calcareous and makes a very fair packing substance. Percentages of rock are 87 limestone, 9 crystallines, 1 chert, 1 slate, and 2 shale. The color in general is of a brown, but those portions which are only a few feet above the ground-water level are gray. This indicates that at a recent time, geologically speaking, the ground-water level in this vicinity was higher than it is at present, otherwise the oxygen of the air would have combined with the various elements of the rocks and have formed oxides, which would give a more or less brownish color because of the changing of the iron to an iron oxide.

This deposit is being worked very little at present on account of its inaccessibility to the roads. However, by cutting away a part of a heath, and removing the slump from the stream bluffs, a pit could be opened where 30 wagons might be loaded at once. These loads would have to be hauled 1-6 of a mile over a level surface to reach a gravel road. About 20 miles of road in this vicinity are said to have been built of this gravel from 10 to 30 years ago, and in all of these cases good satisfaction has been given.

The Pegg deposit occurs beneath the valley slope of a tributary to Cabin Creek, above the ground-water level. The available portion, as far as known, is probably 100 yards long, this length being parallel with the stream course, 25 yards wide and 3 yards deep. The stripping is from 2 to 4 feet. As a road material it is durable and quick to pack. In size 10 per cent. is clay, 15 per cent. fine medium sand, 15 per cent. medium sand, 25 per cent. coarse sand, 10 per cent. roofing pebble, 23 per cent. gravel and 2 per cent. boulder. The rock composition is similar to that of the Clark deposit. The color is a light brown and yellow at the bottom and brown at the top.

Below the ground-water level and in the flood plain of Sparrow Creek, on the farm of J. W. Willis, in the northeast corner of section 3 (19 N., 13 E.), is an area of 30 by 100 yards underlain by a bed of gravel. These limits were determined by a dug well at the house and the exposure at the pit. The depth is 21 feet. The stripping at the pit, which is beside the stream, is 2 feet, but at the well, which is 100 yards from the stream, it is 10 feet.

This gravel is finer than the average, but its unoxidized condition and its good packing quality makes it a durable material. In size, 10 per cent. is clay, 15 per cent. fine medium sand, 24 per cent. medium sand, 32 per cent. coarse sand and 19 per cent. roofing pebble. The rock percentages are about average. Roads are repaired with this gravel for 1 mile south, 2 miles east, 1 mile north and 2 miles west. Because of the fineness this material should be used only for repair work.

In the northeast quarter of section 7 (19 N., 13 E.), on the property of John Merryweather, is a gravel bed which differs from the deposits heretofore described, in being of glacial origin rather than stream. It is apparently a part of the terminal moraine of the late *Wisconsin ice sheet, the topography being of a hummocky type. The extent of the deposit has been roughly determined by two pits, which are 300 yards apart, and a dug well about midway between these, which showed gravel from a few feet of the surface on down to its bottom. Judging from the exposures in the pits, the width of the bed is at least 75 yards. The depth varies from 5 to 25 feet, and the stripping at the pits is from 3 to 4 feet.

The heterogeneous nature of the material permits no uniformity of size. Clay, fine sand, coarse sand and boulders are all mixed together. Frequently the gravel runs out abruptly into a hard clay or a fine sand. Stratification is entirely absent. The rock percentages are 83 limestone, 12 crystalline, 1 chert, 1 slate and 3 shale. The color is of a light brown at the bottom and brown to yellow at the top. The oxidation at and near the top is very pronounced, but is much less at the bottom. Fifteen hundred wagon loads of this material are used annually in building and repairing the roads for 2 miles south, 1 mile east, 1 mile north and 2½ miles west. The high percentage of clay makes it pack very well, but also makes the roads rather muddy in the winter and dusty in the summer.

On the slopes of the valley sides of a tributary to West River, in the southwestern quarter of section 13 (18 N., 12 E.), on Robert Lumpkin's land, are some gravel beds which underlie 20,000 square yards, with a thickness ranging between 5 and 12 feet. The following shows the character of these beds:

*See page 320.

Section from Gravel Pit on Robert Lumpkin's Farm.

	Feet.	Inches.
1. Surface	3	..
2. Dark brown gravel of average size	1	..
3. Brown gravel above the average size	4	..
4. Light brown gravel of an average size	2	6

The average sizes for Nos. 2 and 4 are 10 per cent. clay, 15 per cent. fine medium sand, 10 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 23 per cent. gravel and 2 per cent. boulder. In other parts of the bed the sections show as much as 3 feet of fine sand. The gravel has been used in making 14 miles of road, and is now used in repair work for a couple of miles in all directions. Several miles of the road running north and south past the pit are said to have been built 20 years ago, and since that time the material for repair work has come from this same bed. This road today is smooth and hard. Only in places where the grading and the ditching at the sides have been neglected is the road rough.

On the land of Lewis Johnson, in the central western portion of section 3 (19 N., 12 E.), is the remnant of a glacial kame, which is beneath the ground-water level, covers an area of 4,000 square yards and has a depth of at least 25 feet. The gravel is gray in color and is unoxidized. The rock composition is about average. In size 12 per cent. is clay, 12 per cent. fine medium sand, 10 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 24 per cent. gravel and 2 per cent. boulder. Thirty years ago the road which borders Mr. Johnson's farm on the west, and runs north and south, was built for several miles with the gravel, which was from above the ground-water level, and consequently more oxidized than the present. Since that time the road has been repaired with material from this pit. Today it is smooth, well packed and among the better improved roads of the county.

In the flood plain and on the valley sides of the Little White River, in the northwest quarter of section 27 (19 N., 12 E.), are gravel deposits on the M. C. McGurrill place, occurring interstratified with layers of hardpan. Although several acres are underlain, the size is very good and the gravel is near the road; yet the amount of clay is so great and so mingled with it that it will be useless to attempt dipping in the flood plain. The material above

the ground-water level, because of a scarcity in this vicinity, can be used profitably for a couple of miles west, north or east.

Above the ground-water level in the northwestern corner of section 4 (19 N., 12 E.), on the Fletcher farm, is a gravel bed which is said to underlie several acres. The tests showing this extent have been very general, such as post holes and dug wells. The depth is from 5 to 25 feet. A section at a pit in this bed is as follows:

Section at the Fletcher Pit.

	Feet.	Inches.
1. Stripping	3	..
2. A brown gravel, somewhat below the medium in size	6	..
3. A brown, and very fine gravel	7	..

The sizes of Nos. 2 and 3 are 12 per cent. clay, 20 per cent. fine medium sand, 32 per cent. medium sand, 20 per cent. coarse sand, 11 per cent, roofing pebble and 5 per cent. gravel. This is a very fine gravel; and because of this it has become considerably weathered. Its rock composition is about average.

LIMESTONE.

The available limestone in Randolph County that is suitable for road macadam is found at various points along the Mississinewa River from near Deerfield west to the Henry County border, along the White River from Macksville west, and at several places in the civil townships of Green and Monroe.

On the P., C. & St. L. Railway ½ mile east of Ridgeville, in the southwestern quarter of section 7 (21 N., 14 E.), is located the macadam plant of the Armfield and Cartwright Company. At their quarry, which is 100 feet north of the plant, the following section is exposed:

Section at the Armfield and Cartwright Quarry, Half Mile East of Ridgeville.

	Feet.
1. Gray thin bedded, and fossiliferous limestone	7
2. Gray, dolomitic, thick bedded limestone	15

The limestone No. 1 is very inferior to No. 2 for road building, being softer and more brittle. Its nearness to the surface, its beds

being from ¼ to 4 inches thick and fragmental, and its position above the ground-water level has permitted this rock to become considerably weathered. With No. 2, where the beds are from 4 to 18 inches thick and largely beneath the level of ground water, oxidation has no more than formed a very thin film on the surfaces, along bedding plains and joints. Another very good feature of this portion of the quarry is the almost total absence of clay and other impurities.

During the summer and fall months this crushing plant turns out about 25 carloads of crushed stone daily, and from June 10th until December 24th about 100 men are employed to operate it.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of Niagara Limestone from the Armfield and Cartwright Quarry.**

Specific gravity	2.65	French coefficient of wear.	5.6
Weight per cu. ft. (lbs.)	165.3	Hardness	—7
Water absorbed per cu. ft. (lbs.)	.77	Toughness	6
Per cent. of wear	7.2	Cementing value—Dry	11
		Wet	19

"Below the average in resistance to wear for limestone, also in cementing value. Only fair results should be expected from this rock."†—Page.

A chemical analysis by the chemist at the Road Testing Laboratory shows the composition of the limestone to be as follows:

Chemical Analysis of Niagara Limestone from the Armfield and Cartwright Quarry.

	Per cent.
Alumina (Al_2O_3)	.21
Lime (CaO)	31.25
Magnesia (MgO)	20.10
Phosphoric acid (P_2O_5)	Trace
Insoluble in hydrochloric acid	1.05
Loss on ignition	47.03
Total	99.64

*For standard of comparison see p. 79.

†It is claimed by Messrs. Armfield and Cartwright that the layer of stone from which the samples for testing were taken is much softer and less durable for macadam purposes than that found in the deeper layers new being worked.

The available quantity of this rock underlies an area of 40 acres, and has a known depth ranging between 20 and 40 feet. Below these depths no tests have been made, but the probability is that the stone continues considerably deeper.

The E. T. Botkin plant is just across the river from Macksville. It is small and is only operated during a few months of the year. The physical character of the rock in his quarry is much like that ½ mile east of Ridgeville. Nine miles of the road which runs east and west through Macksville have been built with this material. This road is smooth, hard and much more durable than the gravel. This durability is particularly noticed when the road is used for heavy hauling in the wet season.

In the civil townships of Monroe and Green the stone is said to appear at the surface at a number of places in the stream channels. On the F. W. Green farm, in the southwestern quarter of section 27 (21 N., 12 E.), the limestone outcrops in the bed of a small stream, and, as has been indicated by water wells and gas wells, is within from 7 to 15 feet of the surface for a radius of ½ mile. The quality of the stone is similar to that at Ridgeville and Macksville.

Since this location is about 5 miles from a railroad, and is in a locality where the only available gravel is very limited in amount, of a poor quality, and about 4 miles distant, a small portable stone crusher would be a very good investment. With this from 40 to 50 cubic yards of stone could be crushed daily at an approximate cost per cubic yard of from 50 to 70 cents, depending upon the amount of stripping. This material, because of its availability and durability, which will far excel that of the gravel that is being put on the roads, will be the cheaper and most satisfactory road metal for this vicinity.

WAYNE COUNTY.

Area in square miles	409
Population in 1900	38,970
Miles of public roads	828
Miles of improved roads*	702
Percentage of roads improved	84.7
Miles improved with gravel	702
Miles improved with crushed stone	None
Average original cost of gravel roads per mile*	$1,237
Total original cost of improved roads	$868,500
Annual cost of repairs per mile on gravel roads 5 years old	$75
Satisfaction of farmers with investment in improved roads—	Reasonably well satisfied

Authorities—

R. A. Howard	County Surveyor
H. J. Hanes	County Auditor

*Includes 550 miles of township roads, at an estimated cost of $750 per mile. and 152 miles of county roads, most of which were formerly toll roads, at an estimated cost of $3,000 per mile.

"In answer to your twelfth question, the first improved road in the county was the 'National Road,' built in the years 1835-37; but that was not completed, except in a few short patches. Then the roads were kept up by the two or four-day labor and land tax and donations along the line. The roads were improved to some extent by grading until about the year 1849, when a little gravel was used on a few roads.

"In 1852 the Legislature passed a turnpike road law. Under that law a number of turnpike companies were organized and constructed quite a number of miles of gravel roads. A few roads were constructed under later turnpike laws. But quite a number of roads have been improved by two or four-day labor and road tax and donations along the line. Some of the toll pikes were abandoned and have been kept up by the townships. The others have been purchased by the county and been turned into free pikes." R. A. H.

Near the central part of the eastern boundary of the State, with Richmond as its county seat, is Wayne County. It lies south of Randolph, east of Henry and Fayette, north of Fayette and Union, and west of the State of Ohio. The length from east to west is from 20 to 22 miles, and the width from north to south ranges between 17 and 18 miles.

The rocks of two Geological Periods are represented in the county, viz., the Niagara limestone (Silurian Period), which underlies the Wisconsin drift along the northern and eastern edges; and the Hudson River limestones and shales (Ordovician), which form the bed rock over the greater portion. With the exception of the southeastern part, the entire county is covered with from 100 to 150 feet of glacial drift. The following section may be taken as an average for the upper portion of the drift in this region:

Section through Drift in Wayne County.

		Feet.
1.	Soil	2
2.	Yellow clay	15
3.	Sand and gravel	10
4.	Blue clay and gravel	18
5.	Hard pan	2
6.	Sand and gravel	20
7.	Blue clay and gravel	15

WAYNE COUNTY.

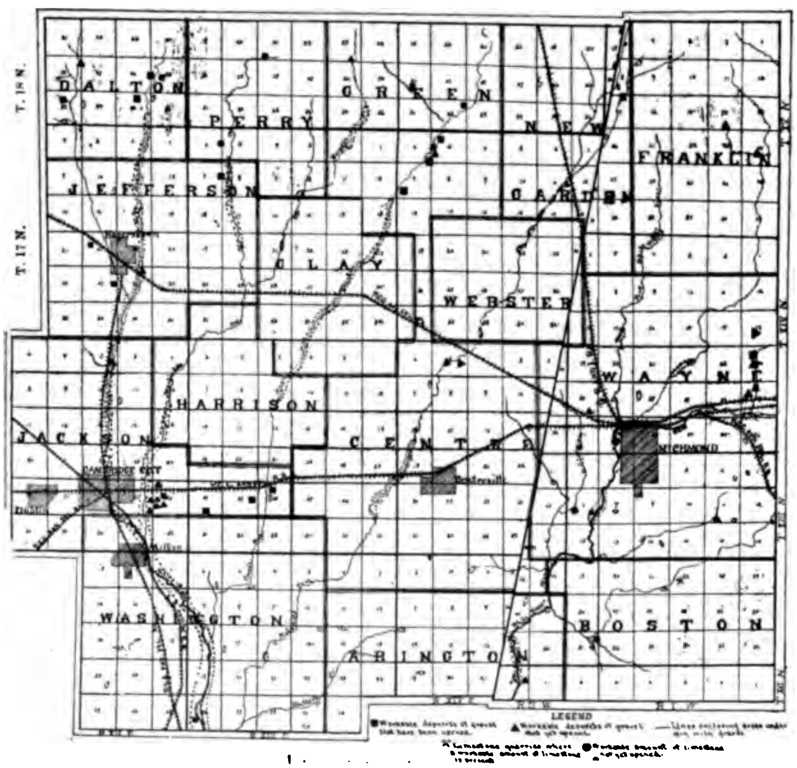

Fig. 29. Map of Wayne County, showing distribution of road materials.

The topography is characterized by the broad stream valleys, such as those of Nettle Creek, West Branch, Martindale Creek, Green's Fork and Noland's Creek. Although the present stream channels are only a few feet deep, the valley floors are from 100 to 150 feet below the summits of the ridges between them. According to Frank Leverett, a member of the United States Geo-

logical Survey, these larger "valleys are cut in a sheet of old drift, over which a thin sheet of later drift has been spread, a sheet whose southern boundary is found in counties immediately south." The gravel plains, which are so well developed along West Branch, Martindale Creek, Whitewater River, and to a less extent along Green's Fork and Noland's Creek, are among the largest deposits, from an economic point of view, in the State, particularly the great bed of gravel which extends from Germantown on south past Milton and down Whitewater River to Beeson's Station. These large deposits are probably the valley trains from the terminal moraine of southern Randolph County, in which these streams have their sources.

Wayne ranks among the first counties of Indiana in amount of gravel, as well as in quality. The average sizes are 8 per cent. clay, 15 per cent. fine medium sand, 12 per cent. medium sand, 20 per cent. coarse sand, 25 per cent. roofing pebble, 19 per cent. gravel and 1 per cent. boulder. Because of this large size the gravel is less *unweathered than where it is finer. The average rock percentages are 89 limestone, 7 crystallines, 1.5 chert, 1.5 shale and 1 slate, with a small amount of sandstone and argillite.

The county is especially well provided with transportation facilities. One division of the Pennsylvania Ry. and the R., D. & I. Traction Ry. crosses along the northern boundary of the southern third of the county; another division of the Pennsylvania Ry. crosses in a southwesterly direction, passing through Richmond, Washington and Hagerstown. The G. R. & I. runs north and south across the southern two-thirds of the eastern third, and the L. E. & W. crosses the southwestern quarter.

GRAVEL.

Township 18 North, Ranges 13, 14 and Parts of 12 and 15 East; and the Northern Three Miles of Township 15 North, Range 1 West.

This area is found along the northern boundary of the county, and is 21 miles long from east to west and 3 miles wide from north to south. It contains the northern and larger portions of the civil townships Franklin, New Garden, Green, Perry and Dalton.

*See page 319.

The deposits of this area are confined largely to the valley sides, terraces and flood plains of Noland's Creek, Green's Fork, Martindale Creek, West River and Nettle Creek.

There are no gravel pits that are being operated in this portion of Franklin Township, but there is a location for dipping, on the farms of I. R. White and Mollie Hunt, in the southeastern quarter of section 14 (15 N., 1 W.), and three other possible locations, one being on the Anderson place immediately southwest of Bethel, in the northeastern part of section 11 (15 N., 1 W.), another on the land of A. L. Wyley, in the flood plain of a small stream valley in the west-central part of section 1 (15 N., 1 W.), and the third in the southeastern quarter of section 11 (15 N., 1 W.), on the property of David Harland. A bank location is found in the R. L. and N. S. Overman property, in the northwestern quarter of section 9 (15 N., 1 W.).

The tests on the White and Hunt farms were made by taking off the stripping with a post hole auger and driving an iron bar into the gravel. These tests showed a depth of gravel on either side of a small creek of 17 feet, a stripping of 3 feet and an extent of 150 by 70 feet. Probably the extent is considerably more, but no further tests have been made. On the Anderson place tests indicate that a fine medium to a coarse sand underlies an area 200 yards long and 50 feet wide, with a depth of 17 feet and a stripping of from 3 to 7 feet. This gravel is too fine for road building or repairing, but since material is so scarce in this locality it might be used for finishing over a crushed limestone road. Even for this use the screenings from the limestone would be much better, because of their cementing qualities. Mr. A. L. Wyley found, by digging, a bed of good gravel beneath 2 feet of stripping, and on the north side of a small creek. No tests have been made to determine the extent. On David Harland's place tests made by means of an iron rod and a post hole auger indicated a bed of gravel extending along a small creek and underlying an area of about an acre. The depth ranges from 3 to 8 feet, and the stripping is from 4 to 6 feet. For such a small depth and so great a stripping it would not pay to set any kind of a machine for lifting the material out.

The bank deposit on the Overman place is located in a hill, and is under from 4 to 9 feet of stripping. Its depth is from 4 to 25

feet, and the extent, as is indicated by the corn dying in dry weather, about 3 acres. Considerable clay is mingled with the gravel, which is rather fine and considerably oxidized. Because of the inavailability, fineness and oxidation this deposit is not workable, and should be used only for very light repair work.

About 200 loads of gravel are gotten annually from Whitewater River in section 13 (15 N., 1 W.). This gravel is not much oxidized, but contains scarcely any clay, and consequently is very slow in packing.

Although the gravel for building and repairing the roads in this part of Franklin Township is obtained from Randolph County, west of Whitewater, and from New Garden Township, the roads are, with the exception of 3½ miles, improved.

The gravel deposits in this northern portion of New Garden Township are along Noland's Creek and its tributaries. The only known workable deposit is located in the northeastern quarter of section 17 (15 N., 1 W.), on the property of L. Purvance, and along the side of a tributary valley to Noland's Creek. It is known to underlie 1½ acres. This is seen from the 600 square yards exposed in the pit walls, post auger holes and the gravel turned up in plowing. The depth is 7 feet and stripping 2 feet.

The weathering is considerable at the top, but little at the bottom. The sizes of material are 10 per cent. clay, 20 per cent. fine medium sand, 10 per cent. medium sand, 10 per cent. coarse sand, 45 per cent. roofing pebble and 5 per cent. gravel. Clay and sand layers are rather frequent. The rock percentages are 88 limestone, 8 crystallines, 1 chert, 2 shale and 1 slate. The color is brown at the top and gray at the bottom.

Annually 1,300 cubic yards of this material, at a cost of 15 cents per cubic yard at the pit, are used on the roads 2½ miles east, 2 miles north, 2 miles south and 1 mile west. These roads, built and repaired by this gravel, are generally hard and smooth, but in places are sandy or clayey. Their durability is about the average for the county.

In the bluffs of Noland's Creek, on the farms of A. R. Boren, northern part of section 19 (18 N., 15 W.), C. Alexander, southern part of section 19 (18 N., 15 E.), and Joseph Brown, central part of section 8 (15 N., 1 W.), are some small, unworkable beds of stratified gravel. The Boren deposit is two-thirds clay and fine

sand, is known to underlie a surface of 100 by 15 yards, has a depth of 7 feet and has 1¼ feet of stripping. The fineness, oxidation and amount of clay makes it only suitable for very light repair work. On the Alexander place the deposit underlies 1,500 square yards, is from 4 to 8 feet deep, has a stripping of 3 feet, and is from brown to a light brown in color. Its percentages of size are 12 clay, 20 fine medium sand, 20 medium sand, 10 coarse sand, 20 roofing pebble, 17 gravel and 1 boulder. The rock composition is 89 per cent. limestone, 7 per cent. crystallines, 1 per cent. chert, 1 per cent. slate and 1 per cent. shale. The wearing quality is about an average for the county, but the limited amount and inaccessibility make the deposit impracticable except for very local use. The Brown deposit has an extent of 100 by 10 yards, is 9 feet deep, is under from 3 to 6 feet of stripping and is from brown to light brown in color. The oxidation is considerable at the top, but little at the bottom. Because of inavailability and limited amount it should only be used locally.

Upon doing some careful testing other gravel beds will be found along this creek, some of which might be workable. The gravel in this locality is an average quality for the county, and is very much needed on the roads, since about half of the roads are dirt, and most of those graveled are in need of repair.

This northern portion of Green Township has its deposits in the terraces and flood plains of Green's Fork and Morgan's Creek. About 30 per cent. of the gravel that is put on the roads is taken from the beds of the creeks. This gravel is not much oxidized, and is therefore equal in durability to the bank gravel; but on account of little clay the roadbeds are not so well packed, and the material is continually working off at the sides.

In the northeastern quarter of section 32 (18 N., 14 E.), on the Frank Williams property, and in the first terrace above the flood plain of Green's Fork, is a stratified bed of gravel underlying about 13,000 square yards. The thickness of the bed is exposed at the pit from 8 to 12 feet, and no bottom to the gravel has been found. The stripping is 2½ feet. In size the material is 9 per cent. clay, 12 per cent. fine medium sand, 10 per cent. medium sand, 20 per cent. coarse sand, 35 per cent. roofing pebble, 13 per cent. gravel and 1 per cent. boulder. The percentages of rocks are

89 limestone, 7 crystallines, 1 chert, 2 shale and 1 slate. The amount of oxidation is about the medium for a bank pit of the county.

This gravel is used in building and repairing roads for 2½ miles north and ½ mile south.

On the land of Manly Stegall, in the central part of section 30 (18 N., 14 E.), and the flood plain of a tributary to Green's Fork, is a gravel bed which, by a few scattered tests, seems to underlie 10,000 square yards. It rests upon a clay bottom, with an average depth of 10 feet and 2½ feet of stripping. In physical character it is a little above the average for the county, since the oxidation is slight, giving the gravel a light brown color. About 300 cubic yards of this material are hauled on to the roads for annual repairing 1 mile north, 2½ miles west and ¼ mile east.

Beneath from 3 to 5 feet of stripping, and underlying an area of 20,000 square yards, is a deposit in the flood plain of Morgan Creek, on the David Baley farm, in section 23 (18 N., 13 E.). Four feet of this bed are above ground-water level and from 5 to 19 feet are below, as has been learned by digging a well and shoveling in the bottom of the pit. No bottom has been found to the gravel. In size 3 per cent. is clay, 10 fine medium sand, 15 medium sand, 20 coarse sand, 30 roofing pebble and 22 gravel. Oxidation is practically nothing, and the color is gray.

Although no tests have been made at this location for setting a dipping machine, the extent, unoxidized condition, and, above all, the fact that there are no known workable deposits nearer than 2½ miles, should make it a very desirable one. In the bottom of the old bank pit tests by pipe driving could be carried on without having to remove much stripping.

In sections 35 (18 N., 13 E.) and 36 (18 N., 13 E.), in the flood plain and adjacent area to Morgan Creek, a deposit, covered with from 3 to 4 feet of stripping and with an unknown depth, is on the farms of John Study and William Duke. The extent of this gravel is not determined, since its location is only known through post hole digging, ditching and an old bank pit. The material is about the average in size. Careful testing will be necessary before any machine for lifting the material is set.

With exception of 3 miles on the western portion of the county

line and 2½ miles on the New Garden line, all but ½ mile of the roads in this part of Green Township have been improved.

Only one gravel bed is operated in the northern 3 miles of Perry Township. It is found in a terrace of Martindale Creek, under 2½ feet of stripping, on the property of L. Swain, in the southwestern quarter of section 21 (18 N., 13 E.). The stratified exposure in the pit shows a thickness of 20 feet and no bottom; and the extent of the surface underlain, as has been learned by very general tests with a post auger, is about 8 acres. Layers of hardpan and fine sand are very common, and because of these any further opening should be preceded by tests.

In rock composition 87 per cent. is limestone, 9 crystallines, 1 chert, 1 slate and 2 shale. The average sizes of two samples are as follows: 9 per cent. clay, 15 fine medium sand, 10 medium sand, 26 coarse sand, 24 roofing pebble, 14 gravel and 2 boulder. The color is brown at the top and gray at the ground-water level, and the oxidation is below the average of the county for beds above the ground-water level.

This material is put on the roads for 3 miles north, 2½ miles east, 3 miles south and ½ mile west. Wherever it is used it seems to give better satisfaction than the creek gravel, because of its packing qualities. In the immediate vicinity the gravel is very much needed, there being 10 miles of dirt road in this portion of Perry Township. Undoubtedly other locations can be found along this creek.

In sections 33 and 34 (18 N., 13 E.) almost all of the road metal is taken from the freshet deposits, in the channels and on the flood plains, of Martindale Creek and its tributaries.

In this northern part of Dalton Township a number of bank deposits are located in the terraces and bluffs of West River and Nettle Creek.

The deposits on the farms of J. H. Thornburg, southeastern quarter of section 35, William Healton, southwestern quarter of section 25, and northwestern quarter of section 36 (18 N., 12 E.), are in the bluffs of West River, and Nelson Weaver's is in a terrace 12 feet above the valley plain. All along these bluffs the farmers plow into the gravel, and the crops for 200 yards back from the face will wither during a dry season. Without much

doubt there is sufficient gravel in these bluffs and flood plains to build and repair the roads of this vicinity for a number of years to come. The pits that have been opened are all within a few rods of the road, and no other locations have been tried.

The best developed of these bluff pits is that of J. H. Thornburg. It is 1/8 mile west of West River, and at a point where the valley is 1/2 mile wide. The gravel occurs in a stratified bed with a thickness of 20 feet, and no other bottom than the ground-water level. It has been worked along the face of the bluff for 70 or 80 feet, and is known to extend back into it for 200 yards, where it gives way to clay. The stripping is only 6 inches on the bluff face, but increases as it runs back.

The quality of this material is about an average for a bank pit of the county. It is brown and oxidized at the top and gray and unoxidized at the bottom. The sizes are 16 per cent. clay, 10 fine medium sand, 20 medium sand, 25 coarse sand, 14 roofing pebble, 14 gravel and 1 boulder. The percentages of rocks are 89 limestone, 9 crystallines, 1 chert, 1 slate and 2 shale.

Because of the numerous pits this gravel is not hauled farther than 1/2 mile for building and repairing roads.

The Weaver bed has been found to have a thickness of 16 feet, to underlie about 20,000 square yards and to have from 1/2 to 2 feet of stripping. The quality is similar to that of the Thornburg pit.

Along the west side of Nettle Creek the stratified beds on the land of Edmund Stanton, in the northwestern quarter of section 33 (18 N., 12 E.), and that of Mrs. J. C. Taylor, in the southwestern part of section 28 (18 N., 12 E.), occur in a ridge. The former has a depth of 18 feet, is beneath from 1 to 3 feet of soil and is workable. The extent of either bed is not known. The quality of the material is about the average for the county. Layers of clay and sand are often met. The amount of clay makes the roads somewhat muddy in the winter and dusty in the summer. Three hundred loads from the former pit and 200 from the latter are used in repairing the roads 1/2 mile north, south and east, and 3 miles west.

Other small pits are found on the C. Dennis place, in the west central part of section 34 (18 N., 12 E.), on that of Mrs. O. Bee-

son, in the northeastern corner of section 28 (18 N., 12 E.), and at several other points. All of these deposits seem to be high in clay, but do very well for local use.

Taken as a whole, this area, extending across the northern portion of Wayne County, is very well supplied with gravel. With exception of the pit in the northeastern quarter of section 17 (15 N., 1 W.) and the central portion of section 30 (18 N., 14 E.) the gravel sells for no higher than 10 cents per cubic yard where the civil township or county keeps the pit clean.

Township 17 North, Ranges 13 and 14, and Part of 12 East; the Southern Three Miles of Township 15 North, and the Northern Three Miles of Township 14 North, Range 1 West, and a Small Part of 2 West.

This area of 125 square miles contains the civil townships Jefferson and Webster, southern parts of Dalton, Perry, Green, New Garden and Franklin, and northern portions of Harrison, Clay and Wayne.

In this area the deposits of Nettle Creek seem to be less abundant. Only in the northeastern part of section 4 (17 N., 12 E.), on the farm of John Ditch, and ½ mile due west of this pit, and at Hagerstown are there deposits which are being used. The Ditch bed is stratified and is located in the east bluff. It has a workable amount of gravel and is 12 feet deep. This bed is made up of alternating layers of fine sand and gravel, which are from 2 to 6 inches in thickness. The gravel in size is 5 per cent. clay, 10 fine medium sand, 10 medium sand, 15 coarse sand, 50 roofing pebble and 10 gravel. The color is a medium brown and the oxidation about average for a bank deposit. The rock percentages are 86 limestone, 10 crystallines, 2 chert, 1 shale and 1 slate.

In the southeastern corner of section 10 (17 N., 12 E.), in the side of a small valley, on the property of T. A. Sells, is a stratified bed of gravel beneath from 1 to 4 feet of stripping. Its depth is 18 feet, and the surface which it underlies is probably 10,000 square yards. A section shows 6 feet of brown oxidized gravel, 4 feet of sand and clay and 8 feet of grayish unoxidized gravel. The size of the gravels is 9 per cent. clay, 10 fine medium sand, 10

medium sand, 25 coarse sand, 30 roofing pebble, 14 gravel and 2 boulder. About 420 cubic yards of this material are put on the roads annually at a cost of 5 cents per cubic yard. These roads are in a fair condition, but could be much improved, as well as most of the roads of this vicinity, by keeping the ditches open at the sides and grading frequently.

Deposits along West River are found at various points, but are especially abundant near the junction of this river with Nettle Creek. All of Hagerstown is underlain with gravel, which is found from 1 to 7 feet beneath the surface. A large bed in the southeastern corner of the town, just east of the P., C. & St. L. Ry., shows a thickness of 30 feet, beneath from 2 to 3 feet of stripping. This material is of a medium size and is used 2 miles north, ½ mile east, 2 miles south and 1 mile west. About ½ mile south of this same railroad, and just outside the city limits, is a stream bluff 100 yards long, where a somewhat more impure form of gravel occurs in large quantities. Immediately west of town, on the John Stonebraker land, is a deposit 15 feet deep, underlying several acres, with a stripping of 2 feet. Without doubt several hundred thousand cubic yards of gravel can be obtained in this vicinity. The selling price of gravel in and near Hagerstown is 5 cents per cubic yard.

Martindale Valley also contains numerous deposits in its bluffs and terraces, but very few pits have been opened because of the large amount that is annually deposited on the flood plains and in the creek bed. About 2,000 cubic yards are taken from this source yearly. This material is very little oxidized, and is said to wear much better than the bluff deposits, which are, especially where the material is fine, considerably weathered. The greatest difficulty is to get this material to pack; and in this respect it is far inferior to that found in the pits, but is better than the creek gravel in the southern part of the county because it contains 2 or 3 per cent. of clay.

One of the two bluff deposits which are being used to any extent is found on the west side of the creek, in the northeastern quarter of section 6 (17 N., 13 E.), on the farm of William Foutz. It has from 1 to 2½ feet of stripping and is known to be 18 feet deep, without any bottom being found. The area underlain is not

definitely determined, but excavations and plowing have shown that it continues back as far as 80 rods from the face of the bluff, where it is beneath 4 feet of stripping and is 12 feet deep. The extent along the bluff face has not been learned; but it is reported that by groundhog diggings, plowing and well records that the bluffs on either side of Martindale Creek are frequently underlain by gravel for several miles south.

The quality is in this locality considered inferior, because of the better durability of the creek gravel, but it is about an average for the county. In size 7 per cent. is clay, 10 fine medium sand, 15 medium sand, 30 coarse sand, 20 roofing pebble, 19 gravel and 1 boulder. This size is frequently interstratified with a fine medium sand, and sometimes grades into it completely. The percentages of rocks are 88 limestone, 8 crystallines, 1 slate, 1 chert and 2 shale.

The other bluff deposit is one mile south, in the northwestern corner of section 8 and the northeastern corner of section 7 (17 N., 13 E.). It is known to underlie 10,000 square yards, has a depth of 11 feet and has from 1 to 2½ feet of stripping. In size and rock composition it is similar to the Foutz gravel, except that it contains less fine sand.

Along Morgan's Creek the gravel is not so plentiful as it is along West River and Martindale Creek. No workable deposits are known, and only a part of the gravel is supplied by the flood deposits. The result is that in sections 16, 15, 10, 11, 3 and 2 (17 N., 13 E.) a large part of the gravel is hauled from Martindale Creek and Green's Fork.

There is a small bank deposit in the first terrace above the flood plain on the land of Isaac Love, in the west central part of section 10 (17 N., 13 E.). It is beneath 3 feet of stripping, has a depth of from 4 to 9 feet above the ground-water level and possibly underlies 4,000 square yards, as has been learned by post auger holes. The depth beneath ground-water level is not known. The size of the material is 7 per cent. clay, 5 fine medium sand, 15 medium sand, 20 coarse sand, 40 roofing pebble and 13 gravel. In places it grades into sand.

Mr. A. T. Ballinger, by digging down in the bed and for 5 rods on either side of a creek which passes through his farm in the

northeastern quarter of section 2 (17 N., 13 E.), found the gravel to underlie an area 80 rods long and 10 rods wide. The depth of the bed was not learned.

Like heretofore, the flood plains, terraces and bluffs of Green's Fork are well supplied. At Williamsburg the trustee of Green Township informed the writer that almost all of the dug wells in the town, after going through a few feet of soil, went through 20 feet or more of gravel. This statement is corroborated by the splendid exposure at the southwestern part of town, where a wall 12 feet high and 60 yards long showed a gravel which in size was 8 per cent. clay, 10 fine medium sand, 15 medium sand, 25 coarse sand, 25 roofing pebble, 15 gravel and 2 boulder, and in rock composition 90 per cent. limestone, 7 crystallines, 1 chert, 1 slate and 1 shale. This deposit had not been worked beneath the ground-water level, and no other bottom was known. Another good exposure is found ½ mile north of town, where 25 feet above the stream a stratified bed 8 to 12 feet thick shows a similar physical character to the previous mentioned deposit. Thirteen thousand square yards have been roughly tested at this location and seem to be underlain by gravel.

Even with this great supply of gravel, at a selling price of 10 cents per cubic yard, 30 per cent. of the road material at Williamsburg, and practically all south until the next congressional township is reached is obtained from the flood deposits.

The intervening area between Green's Fork and Noland's Creek, like those between Green's and Morgan, Morgan and Martindale, Martindale and West, and West and Nettle, has scarcely any gravel deposits. Along Noland's Creek and a few miles east and west in the civil townships of New Garden and Webster no other gravel is used, when the supply is sufficient, than that which is deposited on the valley plain and creek bed by the floods. In case this supply is insufficient, large deposits are known to exist beneath the flood plain and terraces.

A flood plain deposit has been opened along a tributary of Noland's Fork, on the A. Hinshaw farm, in the northwestern corner of section 20 (15 N., 1 W.). It is beneath the ground-water level, has 3 to 4 feet of stripping, a depth of 20 feet and a clay bottom. There is at least 4,000 cubic yards, in other words, enough

for another setting of a dipping machine. This bed has a number of lenses of clay which can not be separated in dipping. The result has been a material high in clay, which packs readily when put on the roads, but softens during the wet weather.

The *endless chain process would allow considerable of this clay to be washed out, and would be more satisfactory. The selling price at the pit was 38 cents per cubic yard.

South of Fountain City about 1 mile are two stratified gravel beds beneath the flood plain of Noland's Creek. The one belongs to the G. R. & I. Ry. Co., and is found just south of where the wagon road crosses the railroad in the west central part of section 12 and the east central part of section 11, and the other is south 1/4 mile, on the land of H. Fulgum, in the southeastern quarter of section 11 (17 N., 14 E.). The former is beneath 2½ feet of stripping, has a thickness of 7 feet above the level of ground water and an unknown depth below, and has a known extent of 15,000 square yards. The sizes are 10 per cent. clay, 15 fine medium sand, 10 medium sand, 20 coarse sand, 20 roofing pebble, 45 gravel. The amount of oxidation is considerable in the upper 2 feet, but rapidly decreases until 4 feet below, where it becomes practically nothing. The latter bed is known to underlie about 1 acre, and otherwise is about the same as the former. The material from these pits has been used for repairing 2½ miles south and 2½ miles west.

Besides these deposits, which are used at times of a scarcity of creek gravel, there are numerous other flood plain deposits which are found to some extent all along Noland's Creek in Webster Township. These beds are known by post auger borings, groundhog diggings and other excavations. East of Noland's Creek there are no deposits of economic importance until the West Fork of Whitewater River is reached, and here they are few and small. This is due to the fact that the head of this river is south of the terminal moraine in which those of the previous mentioned streams are found.

The only known workable deposit along the West Fork of Whitewater River is found in the southeastern corner of section 33 (15 N., 1 W.), on the farm of James Lawler, and in the northeastern

*See page 324.

corner of section 4 (14 N., 1 W.), on the C. J. Wright property. This deposit is under the gentle slope on the east side of the valley. It is covered with from 1 to 2 feet of soil, is from 9 to 20 feet deep and underlies 3½ acres, as has been determined with a post auger. No bottom has been found other than water, and tests have been made to a depth of 5 feet below water level.

The quality of this material is below the average for the county, because of fineness and considerable weathering. The roads built with it are sandy and dusty. Fully three-fifths of the deposit is a fine sand. In rock percentages 90 is limestone, 7 crystallines, 1 chert, 1 slate and 1 shale. Over 2,000 cubic yards of this material, at 10 cents per cubic yard at the pits, are put on the roads annually.

Advancing east from this West Fork of Whitewater River no other deposits of known economic importance are reached until we get within half a mile of the Middle Fork of Whitewater River, on the J. C. Morow place, in the east central part of section 10 (14 N., 1 W.). This bed of stratified gravel rests upon a clay bottom and is found within from 1 to 3 feet of the surface along the valley side. The depth is 9 feet and the extent is undetermined. The quality is considerably below the average because of a large amount of sand, which is so interstratified with the gravel that without a careful screening it is impossible to get rid of it. An average sample will show 10 per cent. clay, 25 fine sand, 15 fine medium sand, 15 medium sand, 15 coarse sand, 10 roofing pebble, 10 gravel. The rock percentages are 90 limestone, 7 crystallines, 1 chert, 1 shale and 1 slate. It is not used farther than ½ mile north, ½ mile west and 1 mile south, and the roads on which it is used are sandy.

On an erosion ridge near the central part of section 13 (14 N., 1 W.), on the John Cook property of the southwest quarter and the Harry Cook property of the northwest quarter, are stratified beds of gravel beneath from ¼ to 1 foot of surface and with a known depth of 15 feet, with no bottom other than gravel having been found. The extent of these beds is not definitely known, but the ridge continues on south for over 2 miles into the next township, and is known to be underlain with gravel at numerous

points. The gravel frequently grades rather abruptly into fine sand, so that careful testing is very essential.

The quality of this material is above the average for the county. It contains a very calcareous clay, which cements the material together thus forming a hard, smooth, and durable road. The sizes, as shown by the average of three samples, were as follows: 10 per cent. clay, 17 fine medium sand, 20 medium sand, 15 coarse sand, 25 roofing pebble, 12 gravel, and 1 boulder. The rock percentages are 89 limestone, 6 crystallines, 3 chert, 1 slate, and 1 shale.

Township 16 North, Ranges 13, 14, and Part of 12 East; and the Southern Three Miles of Township 14 North, and the Northern Three Miles of Township 13 North, Range 1 and a Part of 2 West.

This area of 125 square miles comprises the central part of the county. Taken as a whole, it is one of the very best areas of Indiana for gravel and transportation. The gravel is, in general, of a good size and is durable. For transportation, there are four railroads and one traction line crossing these townships.

In an erosion ridge, near the central part of section 24 (14 N., 1 W.), on the farms of T. L. Porterfield and Charles Weffler, is probably the best bank deposit in the county. It is found in the southern portion of the ridge that the *Cook pits are in. This bed of gravel lies beneath from 2 to 3 feet of stripping, has a thickness of from 10 to 15 feet, with no other bottom than gravel, and a known extent of 400 by 50 yards. This extent has been determined by post auger holes, and the fact that crops die on this ridge during a dry season.

The quality of this material is one of the best in the county; and without a doubt, the part that is beneath the ground-water level is better, because of less oxidation. This higher rank is due to the clay or very fine conglomerate, which is made up of a number of minute grains of rock, with almost a pure lime for a matrix. At the pit, this clay or fine conglomerate has so cemented the gravel together that it comes out in great masses, which have to be broken up. When put on the road this material cements very

*See page 373.

quickly, staying right where it is put. This saves considerable grading, and aids in keeping the side ditches clean. The average size of two samples are 12 per cent. clay, 15 fine medium sand, 23 medium sand, 20 coarse sand, 22 roofing pebble, and 8 gravel. The rock percentages are 89 limestone, 6 crystallines, 3 chert, 1 slate, and 1 shale. About 1,500 cubic yards of this material are put on the roads annually, at a cost of 10 cents per cubic yard at the pit. It is hauled ½ mile east, ½ mile north, 2 miles west, and ½ mile south. Even the hillside roads, where this material is used, are in a good condition, the gravel not washing away as is common for such positions.

In the northwestern quarter of section 25 (14 N., 1 W.), are numerous deposits on the valley sides, stream bluffs, and on the erosion ridges. On Fred F. Jackson's place, in the stream bluff, is a stratified exposure which covers 200 square yards. It shows the bed to be at least 35 feet thick, with a stripping of from 0 to 2 feet. Back 150 feet from this bluff the bed is again found within a few feet of the surface.

Another exposure is on the Joseph White place, of the same quarter section, along a valley side. This bed is known to be 35 feet thick, and contains a workable amount of material. East of this deposit about an eighth of a mile in a stream bluff is an exposure of 150 square yards on the W. I. White farm, which shows a bed with at least a thickness of 20 feet. Across the creek and west of this deposit at the top of a ridge which lies between two creeks is another workable deposit on the W. I. White place. Here a small pit has been opened which shows a bed of gravel from 10 to 35 feet thick. Groundhog diggings show it to underlie at least 2,000 square yards of surface.

All four of these deposits of the northwestern part of section 25 (14 N., 1 W.), are about the same in quality. All contain calcareous clay, which aids the gravel in packing; are weathered near the top of the beds, and not much at the bottom, and have similar rock percentages, which are 89 limestone, 7 crystallines, 2 chert, 1 slate, and 1 shale. The sizes are also very similar, an average being 5 per cent. clay, 18 fine medium sand. 12 medium sand, 25 coarse sand, 20 roofing pebble, 19 gravel, and 1 boulder; and the durability is above the average for the county.

On either side of a young valley, which is situated along the valley slope of the East Fork of Whitewater River, are gravel beds, on the property of Joseph M. Smith, in the west central part of section 36 (14 N., 1 W.). These beds are from 10 to 20 feet thick, but their dimensions are very uncertain, since they seemed to be in pockets and grade into sand very abruptly. However, at least 5,000 cubic yards can be obtained. The size is coarser than most gravel of this county, about 3 per cent. being clay, 10 fine medium sand, 10 medium sand, 30 coarse sand, 18 roofing pebble, 17 gravel, and 10 boulder. The clay, although small in amount, assists very much in the packing. This is readily observed when it is compared with the creek gravel, which is at the bottom of the hill, on the east and west road, running past this deposit. The creek gravel has scarcely any clay, and consequently never becomes well packed. Again, when we compare this Smith gravel with the Porterfield, it, also, seems to pack less freely.

Along the valley sides of Short Creek, deposits are found on the farm of George H. Shute, in the central western part of section 1, on the A. S. Shute place, in the southeastern quarter of section 2, on the property of George Kircher, in the south central part of section 11, and on the Leslie Cook land, in the northwestern quarter of section 16 (13 N., 1 W.). The first of these deposits is 3 feet beneath the surface, rests upon a sand bottom, has an average depth of 12 feet, and an extent of gravel and sand, grading into one another, of about 10,000 square yards, which has been hurriedly tested. The average size of two samples are 3 per cent. clay, 10 fine medium sand, 8 medium sand, 20 coarse sand, 39 roofing pebble, 12 gravel, and 8 boulder. The rock percentages are 87 limestone, 3 chert, 8 crystallines, 1 slate, and 1 shale. This material is used on the roads 1 mile north, ¾ mile west, and 3 miles south. It wears very well, but makes a stony road on the hillsides where the water carries the finer material away, there not being enough and the right quality of clay to cement it.

The gravel bed on the A. S. Shute farm is from 4 to 7 feet beneath the surface, has a clay bottom, is 6 feet thick, and has an unknown extent. This deposit is running into sand and can not be termed workable, unless considerable screening is done. The

quality, with exception of more sand, is similar to the George Shute deposit.

The George Kirscher deposit is beneath from 2 to 3 feet of stripping, has a clay bottom, is 20 feet deep, and has 450 square yards showing on the pit wall. Probably 20,000 cubic yards are accessible, as is indicated by groundhog diggings, back a hundred feet from the pit. The sizes are 7 per cent. clay, 23 per cent. fine medium sand, 10 per cent. medium sand, 10 per cent. coarse sand, 20 per cent. roofing pebble, 29 per cent. gravel, and 1 per cent. boulder. The rock percentages are 88 limestone, 4 chert, 7 crystallines, and 1 shale. This material is used 1 mile west, 1 mile south, and 1½ miles east, in repairing roads, which are in a very fair condition. It packs about like the Shute gravel.

The Cook deposit occurs on both sides of the creek, in the second terrace, above the flood plain, 40 feet above the stream. It rests upon the Cincinnati limestone, is from 2 to 3 feet beneath the surface, has a depth of 9 feet, and a known extent of 1,000 square yards. The sizes are considerably below the average. The rock percentages are 90 limestone, 5 crystallines, 3 chert, 1 slate, and 1 shale. This gravel is too fine for building, but can be used for very light repair work.

All of these deposits along Short Creek are stratified and are considerably oxidized at the top, but not much at the bottom. The gravel, in quality, will hardly reach the average for the county.

In the southeastern part of section 12 (13 N., 1 W.), on the farm of Charles Schwing and on the side of Elkhorn Valley, is a bed of gravel 11 feet deep beneath 4 feet of surface, and extending over 6,000 square yards. The extent was determined by a well 75 yards back from the pit, which showed 15 feet of gravel, and by holes dug with a post auger. The bed has been worked down to ground-water level, but no bottom to the gravel has been found. In a few places the gravel grades into clay. The quality is about an average for the county. About 6 per cent. is clay, 20 fine medium sand, 10 medium sand, 10 coarse sand, 20 roofing pebble, and 15 gravel. Rock percentages are 88 limestone, 9 crystallines, 1 chert, and 2 shale. One thousand loads, at 15 cents each, are used for building and repairing annually as far as ½ mile north, ½ mile west, and 5 miles south.

On the side slopes of an old valley, which has a width of ½ mile, on the farms of Harry Miller and Lee Druley, in the southeastern quarter of section 16 (13 N., 1 W.), are stratified beds of gravel, with no known bottoms, and with from 3 to 3½ feet of stripping. Both of these deposits have depths of about 30 feet, and tested extents of about 3 acres, but the sand and clay are so mingled with the gravel that neither can be termed workable. The sizes are about the same, being from fine sand to a sample which is 4 per cent. clay, 5 per cent. fine medium sand, 5 per sent. medium sand, 5 per cent. coarse sand, 50 per cent. roofing pebble, and 30 per cent. gravel. Rock percentages are 90 limestone, 1 shale, 2 chert, and 7 crystallines. These gravels are used 2 miles north, 1 mile east, 2 miles south, and ½ mile west. Both are slow to pack, and are sandy, unless screening is resorted to. The selling price at the pits is 10 and 15 cents per cubic yard, depending upon which party keeps the pit clean. About 100 cubic yards are sold annually from the Miller pit and 600 from the Druley.

Along the Middle Fork of Whitewater River a deposit is found in the bluffs on the farms of John Burns and J. P. Norris, in the east-central part of section 22 (14 N., 1 W.). This bed is stratified, is under from 4 to 5 feet of stripping, has a known thickness of 20 feet, and an extent of ½ mile up the stream, which has been learned mainly from groundhog diggings. Since this bed frequently grades into sand and clay, it should be carefully *tested before being opened. The material for road building is too fine but serves for light repair work. Because of its fineness, oxidation is considerable. This deposit is rather inaccessible, unless a new road be built to it, and this would not pay unless a large quantity be taken out. To get to the bed from the road, one has to go down a steep grade and over the bluff to a point 50 feet below.

On the farms of D. S. Hoover and H. E. Hoover, in the west-central part of section 28 (14 N., 1 W.), is a deposit in the bank of a tributary to the Middle Fork of Whitewater River. The gravel bed, where exposed, is under 4 feet of fine medium sand, which is overlain by 3 feet of surface. The depth is from 4 to 9

*See page 323.

feet, no bottom having been found, although worked to the water-level. Fence posts, over an area of 100 acres, are set in either gravel or sand, but it is probable that 90 per cent. is a rather fine sand, and great care should be exercised in testing, before opening any pits. This gravel is fine and considerably weathered, and should be screened before being used on the roads. The sizes in different parts of the bed range from a fine sand to a sample which shows 8 per cent. clay, 15 per cent. fine medium sand, 20 per cent. medium sand, 40 per cent. coarse sand, 12 per cent. roofing pebble, and 5 per cent. gravel. Rock percentages are 90 limestone, 7 crystallines, 1 chert, 1 slate, and 1 shale. This gravel is below the average in quality for the county.

About an average in size of material, rock composition and quality is the deposit which is located in a bluff 40 feet above the stream, on the Joseph Jasper property, in the central part of section 8 (13 N., 1 W.). Its stripping is from 2 to 4 feet, bottom clay, depth 12 to 15 feet, and amount 4,000 cubic yards.

In the valley sides and banks of East Lick Creek a number of well-known deposits are found. In the south-central part of section 30 (14 N., 1 W.), are the G. R. & I. Ry. Co., the Ratliff and the James Hanel deposits, which are composed of gravel, clay, and sand. From these, by screening, probably a hundred thousand cubic yards of medium sized gravel could be obtained. These beds range from 10 to 20 feet in depth, are stratified, and are beneath from 1 to 6 feet of surface.

Along the valley sides of the same creek, in section 31 (14 N., 1 W.), on Mrs. James Carman's property, is a material of average size and quality in a workable deposit with a depth of 15 feet and a stripping ranging between 1 and 3 feet. About ½ mile farther south along the same stream the Earlham Cemetery Association has a similar deposit, with the exception that the stripping has increased to 10 feet. This same company has another workable deposit, with similar material, another mile south, in the valley sides of the same creek, in the west-central part of section 7 (13 N., 1 W.). Several acres are underlain here, and the thickness of the bed is 25 feet. Probably as much as 60,000 cubic yards are available.

In the southeastern part of section 7 and northwestern quarter

of section 8 along the Whitewater River are a number of small openings in the bluffs exposing beds of medium sized gravel with a thickness in places of 40 feet. Although ¾ of the material is a fine sand into which the gravel is continually grading, yet by screening several hundred thousand yards would be available.

Along a north and south road in the southwestern quarter of section 13 (13 N., 2 W.), on the W. Conaha land, is a location in the bluff of Padding Run which can be found by digging into the sides of some small gullies. The extent seemed to be about 2,500 square yards, and the gravel was slightly under the medium size.

There is a small deposit of oxidized and under medium sized gravel in the bank of Lick Creek, in the southeastern quarter of section 15 (16 N., 14 E.), on the W. F. Ratliff place. The bed is beneath 4 feet of stripping, and is 8 feet deep. Roads on which this material is used are sandy.

On the terraces of Noland's Creek, on the Daniel Medairis land, in the northeastern quarter of section 7, on the property of J. F. Medairis, in the central part of section 5, and on the M. Grace place, in the northeastern quarter of section 5 (16 N., 14 E.), are known beds of gravel and sand, underlying from 1½ to 4 feet of surface, and having depths ranging from 6 to 12 feet above ground-water level, and unknown depths below. They are about the average for the county, in rock composition and sizes of material. The extent of the first is not known, but is likely small, as the gravel of the pit has graded into sand; that of the second is roughly 10 acres, as has been learned by post auger holes and pit openings; and the third, about 4 acres, as was learned by tests at several points. In the terraces between these deposits there are undoubtedly others of value.

Creek gravel in this vicinity is used to a considerable extent. Its unoxidized condition makes it wear well, but the absence of clay does not allow it to pack, while in these three deposits just described the gravel is thoroughly mixed with from 10 to 15 per cent. of clay, which makes it pack quickly, and *wear almost as well as the creek gravel, in spite of its greater oxidation.

Advancing west in this congressional township no deposits are

*See page 322.

workable until Green's Fork is reached. Almost all of Center Township is supplied with the creek gravel deposited by the floods of Noland's Creek. Without doubt deposits will be opened when they are needed in the broad terraces, which were developed by a valley train of the late Wisconsin ice sheet.

In the bluff of Green's Fork, 1/8 of a mile from the stream, on the R., D. & I. St. Ry. Co.'s property, is a stratified bed of gravel, from 1 to 2 feet beneath the surface, with a known depth of 18 feet, at which point the water level is reached, below which it has not been tested. The area underlain is 5 acres (24,200 square yards), which have been tested at a number of points, to a depth of 7 or 8 feet into the gravel. The quality, as to size and rock composition, is about the average for the county.

Just south of this deposit, and in the Green's Fork, is a deposit with similar physical characteristics, which is also beneath from 1 to 2 feet of stripping, is 20 feet deep, and is known to underlie several acres.

On south of these deposits to the southern boundary of section 28 the bluffs of Green's Fork are almost a continuous gravel bed, The farmer's plow, very frequently, turns up the gravel, and the crops in the higher portions during the dry season wither away. Through section 33 (16 N., 13 E.), the valley of Green's Fork is narrow and the stream gradient higher. The result is that very little gravel is deposited by the floods, but is carried on to where the flood plains again become wide, and the current has greater velocity. The bluffs in this section contain very little gravel.

On the second ridge west of Green's Fork and running parallel with this stream are 6 or 7 acres underlain by gravel, as shown by tests and drying up of crops. These are in the east central part of section 29 (16 N., 13 E.), on the land of John Shroyer. No bottom has been found to this bed, which has a known thickness of 15 feet, and from 1 to 3 feet of stripping. The material is about the average in size for Wayne County, and is used 1 mile north, 2 miles west, 1/2 mile south, and 1 mile east, in repairing the roads.

On the land of William Kimmel, in the south central part of section 31 (16 N., 13 E.), is a stratified bed of gravel on a ridge which is parallel with a tributary of Green's Fork. The depth of

the bed to ground-water level is 25 feet, the stripping is 6 inches, and the extent, which has been determined by outcrops on either side of the ridge and some excavations on top, is 6 acres. The quality is about the Wayne County average. It is used 1 mile north, 3 miles east, and 1 mile west.

On the valley side of Martindale Creek are numerous deposits. In the southeastern corner of section 14 (16 N., 12 E.), on the Mrs. John Overpeck place, and in the northeastern corner of section 23 (16 N., 12 E.), on the Edmund Bartsch land, is a bed of gravel that has been reached by the plow over an area of several acres. Where an old pit was opened it was 11 feet deep and was of an average in size, rock composition, oxidation, and in packing on the roads.

Immediately northwest of East Germantown, on the L. Boyd farm, is a deposit of several acres, with a depth of 20 feet, which seems to connect up with the large deposit south of town belonging to the Pennsylvania Railway Company. This is one of the largest deposits which has been tested in central Indiana. It is known, by test pits, to extend ½ mile south of the pit and ¼ mile east. The depth is from 10 to 20 feet above ground-water level, with an unknown depth beneath. A section is as follows:

Section of the Pennsylvania Railway Company's Gravel Pit at East Germantown.

		Feet.
1.	Stripping	1 to 7
2.	A coarse brown material, made up mainly of roofing pebble and gravel	2
3.	Principally, a brown fine medium and medium sand	1
4.	A medium and coarse sand	2
5.	Same as No. 3	1
6.	Same as No. 2	2
7.	Fine sand	1
8.	Similar to No. 3, but is less weathered	3
9.	Similar to No. 4, but is less weathered	2
10.	Similar to No. 2, but is less weathered	1
11.	A gray material beneath water level	Unknown

About 2,000 cubic yards are hauled out of this pit daily for ballast on the railroad, it being used as far as 125 miles from this point. The quality of this gravel is about an average for the deposits which are being worked in the county. It as a bed merges somewhat into a rather fine sand in places, and probably

is made up of about 1 per cent. of hardpan, which occurs in layers.

Following Martindale Creek down stream and then Whitewater River on south we find the valley sides, terraces, and flood plains to contain extensive deposits all the way to the southern border of this township.

On a ridge between two tributaries of the West Branch of Whitewater River, on the W. E. Myers farm, in the southwestern corner of section 11 (16 N., 12 E.), is a bed of gravel underlying at least several thousand square yards with a depth of 10 feet, a stripping 2½ feet and no bottom except gravel at water level. The size and oxidation are about average.

In the south central part of section 15 (16 N., 12 E.), where the West Branch of Whitewater River and a tributary join on the point of a ridge on the John H. Kepler land and under 2½ feet of surface is a workable bed of gravel, 15 feet of which are above water level, and an unknown thickness below. The size is above and the oxidation below the average. This material is used 2 miles north, 2 miles east, 2 miles south, and 1 mile west.

The Greater Part of Township 15 North, Ranges 13, 14, and Part of 12 East, and the Southern Three Miles of Township 13 North, and the Northern Mile of Township 12 North, Range 1 and Part of 2 West.

All along in the bluffs, valley sides, terraces, and flood plains of Whitewater River, there are very extensive deposits. Near the southern border of the county along the valley sides of Whitewater River, in the southeastern corner of section 25 (15 N., 12 E.), on the F. R. Beeson land, the L. E. & W. Ry. Co. has taken out gravel beneath 15 or 20 acres, to a depth of 25 feet, which reached the ground-water level. Beneath the ground-water level the company drove a pipe to a depth of 35 feet and failed to reach the bottom of the bed. The quality as to size, oxidation, and rock composition is similar to that belonging to the Penn. Ry. Co. at East Germantown, but the extent is not so well determined.

West of Whitewater River there are no deposits of economic importance except a bed which contains a large amount of fine

sand and hardpan, on the W. Williams property, in the southeastern quarter of section 22 (15 N., 12 E.). This bed is 10 feet deep, very limited in extent, and contains a material which is below the medium in size, considerably oxidized, and of an inferior quality. It is used for 1 mile north, ½ mile west, ½ mile east, and 1 mile south, in repairing roads. These roads are sandy and dusty in the summer and muddy in the winter.

In the southwestern quarter of section 17 (15 N., 13 E.), several acres are underlain by gravel which is a little below the average in size on the farm of J. W. Judkins. This bed occurs beneath from ½ to 2 feet of stripping, and has a thickness of 9 or 10 feet.

On the valley side of Green's Fork, in the southeast corner of section 6 (15 N., 13 E.), on the land of Charles Wolford, is a stratified bed of gravel underlying a couple of acres with from ½ to 2 feet of stripping. The depth above water level is 9 feet. The size is below and the oxidation above the average.

In the south bluff of Green's Fork, on the Miller farm, in the southeast corner of section 5 (15 N., 13 E.), is a stratified bed of gravel, a little coarser than the Wolford, but still below the average in size. It is 12 feet deep and underlies about 2,000 square yards.

Because of a large amount of gravel being deposited annually in the flood plains of Noland's Fork, no pits are located in its immediate vicinity. At the south central part of section 16 (15 N., 13 E.), 1,000 cubic yards were obtained last year. This gravel is little oxidized, coarser than the bank, and much more durable, but requires more work in grading in order to keep it on the roads. Its looseness is also an impediment to traffic.

Along the valley of Butler Creek are small deposits on the Mrs. E. Roberts farm, in the south-central part of section 27 (15 N., 13 E.), and in the northeastern quarter of the same section, on the property of John Pierce. Both of these deposits contain considerable fine sand and clay, and are much oxidized. The former underlies a couple of acres, as is seen from groundhog diggings. Its size and durability is below the average. The latter deposit is of a very poor quality, being no more than a fine medium sand and a medium sand.

In a low ridge on the J. S. Henwood place, in the north cen-

tral part of section 14 (15 N., 13 E.), is a small deposit under 3 feet of surface, with a depth of 7 feet, and resting upon a clay bottom. The gravel is slightly below the average in size, and considerably below in quality, because of oxidation. It grades into sand very abruptly and contains hardpan layers. Although these low ridges are common in this vicinity, and are known to contain more or less gravel, it will pay to make careful tests and estimates as to accessible amounts before opening any pits.

Another deposit similar in quality is found in a ridge which extends for about 200 yards along Butler Creek, in the northwestern corner of section 18 (15 N., 14 E.), on the W. Wright place. This bed is 7 feet thick, has a clay bottom, and 3½ feet of stripping. Its extent is not determined, but the deposit, which is 20 feet above the stream, is known to be present at other points in the ridge. Probably 2,000 cubic yards could be obtained from this place.

A deposit from which 5,000 cubic yards of a sandy gravel can be obtained is in the northwestern quarter of section 4 (15 N., 14 E.), on the H. Otten property. The depth of the bed is 15 feet, and stripping from 1½ to 4 feet. The material is a little below the average in size, and about the average in oxidation.

Along the valley sides, and on the terraces, and flood plains of Whitewater River are many good deposits, which are not opened, because of the great abundance of creek gravel. However, the pit gravel, because of its packing qualities, gives better satisfaction than the more durable creek gravel, which is exceptionally free from clay in this vicinity. The roads built by it never become well packed, and wagons passing over them are hauled with difficulty. Because of the accessibility of material, the writer would suggest a creek gravel base and a pit gravel dressing.

At John Smelser's house, which is 1-3 of a mile from the river and along one of its tributaries, in the southeastern quarter of section 23 (13 N., 2 W.), a well 21 feet deep was in gravel for the last 14 feet.

On the second terrace of Whitewater River, about 25 feet above the stream, are several acres underlain by gravel, on the Henry Brumfield and Moore properties, just north of Abington. This bed is covered with from 2 to 5 feet of surface, and is 10 feet

deep. The size of the material is very coarse, being 8 per cent. clay, 17 per cent. fine medium sand, 10 per cent. medium sand, 15 per cent. coarse sand, 5 per cent. roofing pebble, 45 per cent. gravel, and 5 per cent. boulder, and the oxidation is below the average. The high per cent. of boulders is the most objectionable feature.

Across the river from these deposits, in a bluff, 60 feet above the stream bed, is a workable deposit belonging to N. W. Williams. It follows the bluff for a couple of hundred yards, is 9 feet deep, and has from 3 to 6 feet of stripping. The material is about the average in size and quality, and has a rock composition of 90 per cent. limestone, 8 crystallines, 1 chert, and 1 slate. It is used on the road for 2 miles east. As in the case of all the pit gravel in this vicinity, the selling price is 8 cents per cubic yard.

On the J. T. Heinbaugh land, in the southwestern quarter of section 31 (13 N., 1 W.), is a deposit located in a stream bluff. It is estimated, by rough tests, to extend back from the face of the bluff for 50 yards, and to follow it for about 100 yards. The size is below the average, and the percentages of rock are 88 limestone, 10 crystallines, 1 chert, and 1 shale. The material is used on the roads for 4 miles north, 1½ miles south, ½ mile east, and 1½ miles west.

Extending through a vertical distance of 45 feet and 150 yards horizontally is a gravel bed from 50 to 100 feet above the stream in the bluff of a tributary to Elkhorn Creek, in the eastern central part of section 31 (13 N., 1 W.), on the T. J. Lamb farm. It is beneath from ½ to 4 feet of surface. Layers of hardpan from ½ to 2 feet thick are met at different beds, and large lenses of fine sand are common. The quality stands as one of the first for Wayne County, because of an almost pure lime cement, in the form of a very fine conglomerate, with a matrix of calcium carbonate. In the bed the gravel is so well cemented together that it has to be blasted out. The sizes are 11 per cent. clay or fine conglomerate, 12 per cent. fine medium sand, 15 per cent. medium sand, 12 per cent. coarse sand, 20 per cent. roofing pebble, 28 per cent. gravel, and 1 per cent. boulder; oxidation is below the average; and the rock percentages are 88 limestone, 8 crystallines, 1 chert, 2 shale, and 1 slate. The material is used on the roads for 1½ miles north, 5 miles east, and 5 miles south.

On the second stream terrace above the flood plain of Elkhorn Creek, on the D. W. Sheffer place, in the southeastern corner of section 21 (13 N., 1 W.), is a bed of gravel with from 1½ to 3 feet of stripping, a thickness of 12 feet, and a known extent, which was determined by post auger borings, of 6,000 square yards. Since the amount of good gravel that is accessible is somewhat doubtful, because of a grading into sand in places, a careful *testing will be necessary. The sizes are, on an average, about 4 per cent. clay, 10 per cent. fine medium sand, 15 per cent. medium sand, 15 per cent. coarse sand, 40 per cent. roofing pebble, 14 per cent. gravel, and 2 per cent. boulder. The rock percentages are 90 limestone, 3 chert, 6 crystallines, and 1 shale. About 800 cubic yards, at from 15 to 20 cents each, are used in building and repairing the roads, annually, for 2 miles north, 2 miles east, 10 miles south, and 1 mile west. The main objection to these roads is that they are stony. This difficulty could easily be avoided by screening.

No deposits of economic importance are found east of these mentioned, unless it be along a small stream and near to the road, on the farms of H. L. Meyer and William Miller, in the northwest quarter of section 4, near the wagon road, which runs west from Boston. Here the writer found material of a medium size lying on the surface at several places in the small valley side where the groundhogs had been digging. He also succeeded in reaching it at several other points with a spade which showed a couple of hundred square yards of surface to be underlain. East of this location the evidence for beds of economic importance is lacking. A large number of dug well records show these beds to be only a few feet at most in thickness.

Limestone.

Limestone that is available and of economic importance is found in the beds of Whitewater River, at and south of Richmond; along Elkhorn Creek in section 22 (13 N., 1 W.); in section 5 (15 N., 13 E.), and 33 (15 N., 13 E.) of Green's Fork; and at other points in the stream channels that the writer did not see. All of this stone belongs to the Hudson River Series and to

*See page .

the Ordovician period. It has a bluish color, is very fossiliferous, and generally rather thin bedded.

On the land of Albert Steen, in the southwestern quarter of section 22 (13 N., 1 W.), at least 10,000 cubic yards of rock are available. This rock occurs beneath about 6 feet of stripping in a bed which has a thickness of 4 or 5 feet. It occurs in layers ranging from a fraction of an inch to 8 inches in thickness. The stone is bluish in color, is very fossiliferous, and in general is a good sample of the stone mentioned in the previous paragraph.

Since this location is 5 miles from a railroad, and is in a locality where the gravel is very limited in amount, there being none in the county south and west of this place, a small portable stone crusher would be a good investment. With this, 50 cubic yards of stone could be crushed daily at an approximate cost per cubic yard of from 50 to 70 cents, depending upon the amount of stripping. This material, because of its availability and durability, which will far excel that of the gravel that is being put on the roads, will be the cheaper and most satisfactory road material for the vicinity west and south.

The results of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of Cincinnati Limestone from the Albert Steen Quarry.**

Specific gravity	2.7	French coefficient of wear	6.9
Weight per cu. ft. (lbs.)	168.4	Hardness	9.6
Water absorbed per cu. ft. (lbs.)	89	Toughness	6
Per cent. of wear	4.5	Cementing value—Dry	15
		Wet	28

"Best suited for highway and country road traffic."—Page.

Chemical Analysis of Cincinnati Limestone from the Albert Steen Quarry.

	Per cent.
Alumina (Al_2O_3)	.35
Iron oxide (Fe_2O_3)	.51
Lime (CaO)	55.00
Magnesia (MgO)	Trace
Phosphoric acid (P_2O_5)	.54
Insoluble in hydrochloric acid	2.15
Loss on ignition	41.33
Total	99.88

*For standard of comparison see p. 79.

UNION COUNTY.

Area in square miles	162
Population in 1900	6,748
Miles of public roads	280
Miles of improved roads*	251
Percentage of roads improved	89.6
Miles improved with gravel	251
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$600
Total original cost of improved roads	$150,600
Annual cost of repairs per mile on gravel roads 5 years old	$275
First improved roads built	1848
Satisfaction of farmers with investment in improved roads	Good
Authority	Clinton Gardner, County Auditor

*All improved roads were built by the townships.

Union County lies west of the boundary line of the State of Ohio, east of Fayette and southern Wayne, south of Wayne and north of Franklin County. The average length from north to south is 14 1-6 miles and the width is 12 miles.

In almost all the valleys of the East Fork of Whitewater River and its tributaries, which traverse the western portion of the county, from north to south, are outcrops of the Cincinnati limestone of the Ordovician period. The broad valley of the East Fork of Whitewater River is 100 feet or more below the adjacent upland, while the area east has a smooth surface, which is due to a covering of glacial drift having filled up the valleys. The drift is from 20 to 40 feet on the uplands and as high as 200 feet in the lower valleys.

The quality of the gravel of the county is considerably above the average for central Indiana. The average sizes of the material are 9 per cent clay, 15 per cent. fine medium sand, 12 per cent. medium sand, 20.5 per cent. coarse sand, 24 per cent. roofing pebble, 17 per cent. gravel and 2.5 per cent. boulders; and the average rock percentages are 85 limestone, 10 crystallines, 3 shale, 1.5 chert, and 1.5 slate.

The transportation facilities of the county are very poor, there being only one division of the C., H. & D. traversing it from the northwest to the southeast.

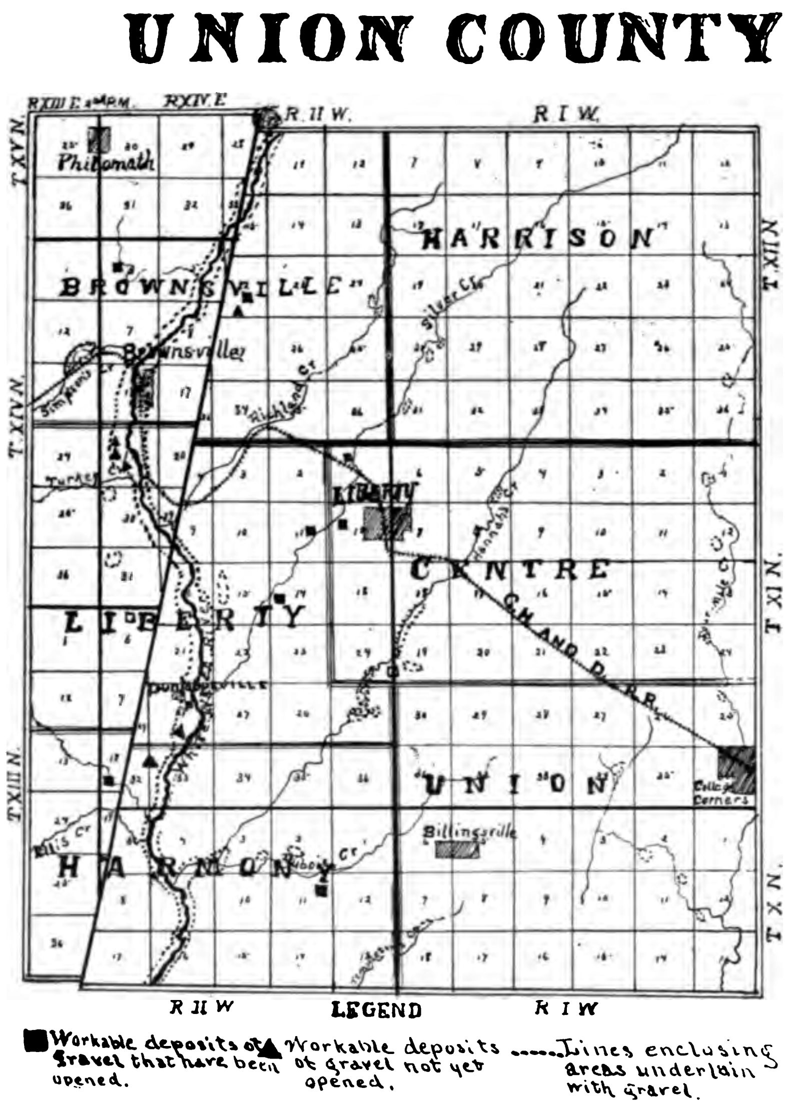

Fig. 30. Showing the distribution of road materials in Union County.

Gravel.

Township 14 and Part of 15 North, Parts of Ranges 13 and 14 East; and the Southern Five Miles of Township 12 and the Northern Three Miles of 11 North, Range 1 and Part of 2 West.

This area comprises the northern 4-7 of the county. All its gravel deposits which have been opened and worked are confined to the stream bluffs, but other good deposits are known to be present in the terraces and flood plains of the East Fork of Whitewater River and Silver Creek. No workable deposits occur in the eastern 1-3 of this area, and none at all in the northeast half of the civil township of Harrison.

On a tributary of the East Fork of Whitewater River in the northwest quarter of section 6 (14 N., 14 E.) on the farm of J. Dodgeridge is a bed of gravel in the bluff, with a clay bottom, a depth of 30 feet and a stripping of from 2 to 4 feet. The occurrence is known for 150 yards along the face of the bluff. The rock composition is about the average and the size of the material is a little below.

A bed of gravel, which has an extent of 30 by 130 yards, is found on the land of H. Whetsel in the southeast quarter of section 18 (14 N., 14 E.) in the bluff of a stream. The thickness is 20 feet and the stripping 1 foot. The rock composition is about average and the size of the material above.

A very large deposit, where two hundred thousand cubic yards of a good quality of gravel could probably be obtained, is found in the west bluff of Whitewater River in the western half of section 19 (14 N., 14 E.), ½ mile south of Brownsville and ½ mile from the C., H. & D. railway. The upper edge of this bluff is 150 feet above the higher terrace, and the gravel exposed in it is found in the sides of 4 or 5 little gullies, which have worked their heads back into it for a few hundred feet. A dug well which is situated 40 feet back from the bluff face showed gravel for a depth of 60 feet. The average of several samples showed the following rock percentages: 85 limestone, 13 crystallines, 1 shale, and 1 slate.

Very good qualities of gravel are found in the northwest corner of section 30 on the G. Hollingsworth place, and in the northwest

quarter of section 31 (14 N., 14 E.) on the J. Beck property. Both contain from 1 to 3 feet of stripping, have known depths of about 10 feet, without finding any bottom, and are probably workable. These deposits are about the average for rock composition, but are a little larger for size.

Located about 200 yards back from the east bluff of the East Fork of Whitewater River is a hill which rises 25 feet above the adjacent region and which has a surface area of ½ acre underlain by gravel. The depth of this bed is 15 feet and the stripping is from 1 to 2 feet. The size of the material is considerably above the average, and the amount of oxidation below. This road metal, at a cost of 20 cents per cubic yard, is used for 2 miles north in repairing and building roads. In the southwest quarter of section 15 (11 N., 2 W.) on the east bluff of the East Fork of Whitewater River, an area of 100 by 200 yards is known, by plowing and groundhog diggings, to be underlain with gravel and fine sand.

A coarse gravel, containing a good many boulders, is found in the east bluff of the East Fork of Whitewater River on the property belonging to C. Immel in the west-central part of section 22 (12 N., 2 W.). This deposit underlies at least a surface of 40 by 150 yards, and has a depth of 35 feet and a stripping of 1 to 3 feet. The rock percentages are 87 limestone, 11 crystallines, 1 shale, and 1 slate. The size, which is considerably above the average, and the small amount of oxidation, makes this a very durable road metal.

Besides the deposits mentioned that occur in the bluffs of the East Fork of Whitewater River in these congressional townships, many others are known to be present. Also large deposits occur beneath the terraces and flood plains. Some gravel is deposited annually in river bars which, because of its accessibility, is used on the river roads.

Several small deposits have been found in the bluffs of Richland Creek. Among these are the deposits on the farms of S. Caldwell in the northwest quarter of section 3 (11 N., 2 W.), C. Davis in the south-central part of section 34, C. Martin in the southeast quarter of section 24, and Mrs. R. Snyder in the southeast quarter of section 24 (12 N., 2 W.).

The Caldwell and Davis deposits are continually grading into fine sand and clay, and can not be termed workable. They rest upon clay bottoms, are from 7 to 8 feet deep, have from 2 to 5 feet of stripping, and contain a material about average in size and rock composition. The Martin and Snyder deposits also rest upon clay bottoms, have from 1 to 3 feet of stripping, a depth of 13 feet, and average materials for size and rock composition. Taken together, these two latter deposits would likely furnish a workable amount of gravel.

In the bluffs of Silver Creek deposits have been opened on the places of S. Corrington in the west-central part of section 14, W. H. Stevens in the southeast quarter of section 11, Mrs. V. Haworth in the northwest quarter of section 14, and J. Carson in the northwest quarter of section 1 (11 N., 2 W.); and C. Martin in the northwest quarter of section 31 and J. Kitchel in the northeast quarter of section 30 (12 N., 1 W.).

On the Corrington place the bed rests upon a clay bottom, has a thickness of 30 feet and a stripping ranging between ½ and 2 feet. The surface known to be underlain is 100 by 150 yards. An average sample shows about 88 per cent. limestone, 6 per cent. crystallines, 5 per cent. shale, and 1 per cent. chert.

Six hundred cubic yards of this gravel, at 20 cents each, are used for 2½ miles east, 1½ miles south, and 1½ miles north in the annual building and repairing of the roads, which are hard, smooth and durable.

The Stevens deposit contains from 2 to 10 feet of stripping, has a depth of 30 feet and underlies a tested area of 60 by 150 yards. For rock composition, the gravel is about the average but above in size.

The Haworth deposit outcrops for over 200 yards along the bluff, has a depth of about 25 feet and a stripping ranging between 2 and 8 feet. Excepting the fine sand and clay into which the material frequently merges, an average of three samples gave the following sizes: 7 per cent. clay, 12 per cent. fine medium sand, 8 per cent. medium sand, 20 per cent. coarse sand, 30 per cent. roofing pebble, 22 per cent. gravel, and 1 per cent. boulder. The rock percentages are 88 limestone, 6 crystallines, 4 chert, and 2 shale. The wearing quality of this material is very good, but

quarter of section 31 (14 N., 14 E.) on the J. Beck property. Both contain from 1 to 3 feet of stripping, have known depths of about 10 feet, without finding any bottom, and are probably workable. These deposits are about the average for rock composition, but are a little larger for size.

Located about 200 yards back from the east bluff of the East Fork of Whitewater River is a hill which rises 25 feet above the adjacent region and which has a surface area of ½ acre underlain by gravel. The depth of this bed is 15 feet and the stripping is from 1 to 2 feet. The size of the material is considerably above the average, and the amount of oxidation below. This road metal, at a cost of 20 cents per cubic yard, is used for 2 miles north in repairing and building roads. In the southwest quarter of section 15 (11 N., 2 W.) on the east bluff of the East Fork of Whitewater River, an area of 100 by 200 yards is known, by plowing and groundhog diggings, to be underlain with gravel and fine sand.

A coarse gravel, containing a good many boulders, is found in the east bluff of the East Fork of Whitewater River on the property belonging to C. Immel in the west-central part of section 22 (12 N., 2 W.). This deposit underlies at least a surface of 40 by 150 yards, and has a depth of 35 feet and a stripping of 1 to 3 feet. The rock percentages are 87 limestone, 11 crystallines, 1 shale, and 1 slate. The size, which is considerably above the average, and the small amount of oxidation, makes this a very durable road metal.

Besides the deposits mentioned that occur in the bluffs of the East Fork of Whitewater River in these congressional townships, many others are known to be present. Also large deposits occur beneath the terraces and flood plains. Some gravel is deposited annually in river bars which, because of its accessibility, is used on the river roads.

Several small deposits have been found in the bluffs of Richland Creek. Among these are the deposits on the farms of S. Caldwell in the northwest quarter of section 3 (11 N., 2 W.), C. Davis in the south-central part of section 34, C. Martin in the southeast quarter of section 24, and Mrs. R. Snyder in the southeast quarter of section 24 (12 N., 2 W.).

The Caldwell and Davis deposits are continually grading into fine sand and clay, and can not be termed workable. They rest upon clay bottoms, are from 7 to 8 feet deep, have from 2 to 5 feet of stripping, and contain a material about average in size and rock composition. The Martin and Snyder deposits also rest upon clay bottoms, have from 1 to 3 feet of stripping, a depth of 13 feet, and average materials for size and rock composition. Taken together, these two latter deposits would likely furnish a workable amount of gravel.

In the bluffs of Silver Creek deposits have been opened on the places of S. Corrington in the west-central part of section 14, W. H. Stevens in the southeast quarter of section 11, Mrs. V. Haworth in the northwest quarter of section 14, and J. Carson in the northwest quarter of section 1 (11 N., 2 W.); and C. Martin in the northwest quarter of section 31 and J. Kitchel in the northeast quarter of section 30 (12 N., 1 W.).

On the Corrington place the bed rests upon a clay bottom, has a thickness of 30 feet and a stripping ranging between ½ and 2 feet. The surface known to be underlain is 100 by 150 yards. An average sample shows about 88 per cent. limestone, 6 per cent. crystallines, 5 per cent. shale, and 1 per cent. chert.

Six hundred cubic yards of this gravel, at 20 cents each, are used for 2½ miles east, 1½ miles south, and 1½ miles north in the annual building and repairing of the roads, which are hard, smooth and durable.

The Stevens deposit contains from 2 to 10 feet of stripping, has a depth of 30 feet and underlies a tested area of 60 by 150 yards. For rock composition, the gravel is about the average but above in size.

The Haworth deposit outcrops for over 200 yards along the bluff, has a depth of about 25 feet and a stripping ranging between 2 and 8 feet. Excepting the fine sand and clay into which the material frequently merges, an average of three samples gave the following sizes: 7 per cent. clay, 12 per cent. fine medium sand, 8 per cent. medium sand, 20 per cent. coarse sand, 30 per cent. roofing pebble, 22 per cent. gravel, and 1 per cent. boulder. The rock percentages are 88 limestone, 6 crystallines, 4 chert, and 2 shale. The wearing quality of this material is very good, but

the stripping is increasing so rapidly that the deposit is worked with some difficulty.

On the Carson property the material is of the average rock composition and size. The deposit rests upon a clay bottom, has a depth of 28 feet and a stripping of from 3 to 5 feet. It has been found along the bluff for 250 yards and back from its face for 25 yards. Six hundred cubic yards, at a cost of 20 cents each, are put on the roads annually for 1½ miles southeast.

Both the Martin and Kitchel deposits rest upon clay bottoms and are probably workable. The former has from ½ to 2 feet of stripping and a depth of 13 feet. The latter contains from 2 to 6 feet of stripping and has a depth of 8 feet. The size of the material for both is below the average and the rock percentages are 80 limestone, 12 crystallines, 6 shale, 1 slate, and 1 chert. Hannah's Creek affords a considerable amount of creek gravel, at the bends and places where the current slackens. In this congressional township no good deposits have been opened in the terraces or bluffs.

A poor quality of gravel, because of oxidation and fineness is found in the bluffs of Four Mile Creek. On farms belonging to J. McCray, in the east-central part of section 1, near the center of 12, and in the north-central part of section 13 (11 N., 1 W.), are beds of gravel resting upon clay bottoms, and with depths ranging between 3 and 7 feet. The rock composition is above average and the size of material and amount of weathering a little below. The areas underlain are undetermined.

The Northern Three Miles of Township 11 and the Southern Three Miles of 10, Range 1 and Part of 2 West; and Township 13 North, Range 13 East.

A rather poor quality of gravel occurs in small pockets, in the bluffs of a tributary to Four Mile Creek. Pockets have been opened on the farms of W. Goble, in the southwest quarter of section 12; J. Smally, in the northeast quarter of section 11 and the southwest quarter of section 2 (10 N., 1 W.). The Cline bed rests upon a clay bottom, has a depth ranging between 1 and 5 feet and a stripping of from 3 to 6 feet. In rock composition the gravel is about average, but low in size. This material has

been used in the building and repairing of the roads for 4 miles west, 2½ miles north, 2 miles east, and 3 miles south; but does not wear well. West from these deposits no others are known until we come to Templeton, Dubois and Hannah's Creek.

A material of average rock composition and somewhat low in size is found in the bank of Templeton Creek, on the place of A. Ardery in the south-central part of section 7 (10 N., 1 W.). The depth is 4 feet to ground-water level, and the stripping varies between 4 and 7 feet. The gravel occurs for 100 yards along the stream, but a further extent is undetermined.

A bed of gravel resting upon a clay bottom, with a thickness of 20 feet and a stripping ranging between 6 and 10 feet, is found for 200 yards along the face of the north bluff of Dubois Creek, on the farm of N. McMahan, in the northeast quarter of section 11 (10 N., 2 W.). The quality, size and rock composition are about the average.

In the bluff of the same creek, on the property of Mrs. E. Abernathy, is a bed of somewhat finer material than the McMahan.

Between two tributaries of Dubois Creek and just back of their junction is a bed of gravel at the end of a ridge, which has been learned by a number of tests to be 60 yards long, 40 yards wide and 30 feet deep. The size of the material is a little below the average. On the side of a ridge, between Hannah's Creek and a tributary, is a bed of gravel, on the land of Mrs. M. Stanton, in the southeast quarter of section 24 (11 N., 2 W.), which rests upon a clay bottom, with a thickness of from 7 to 13 feet and a stripping of from 1 to 6 feet. The surface underlain is 100 by 100 yards, and the size, rock composition and quality are about average.

A similar gravel for quality is found on the Mrs. M. White farm in the southwest quarter of section 19 (11 N., 1 W.). This deposit occurs for 150 yards along a bluff of a tributary to Hannah's Creek, has a depth ranging between 7 and 14 feet, and a stripping between 1 and 6 feet. Both this material and the Stanton are used for 6 miles east and 3 miles north in the building and repairing of the roads. These roads are smooth, durable and giving good satisfaction.

A bed of gravel is known to occur in the bluff of a tributary to

Hannah's Creek for 100 yards on the land belonging to M. Creek in the northeast quarter of section 25 (11 N., 2 W.). The thickness is 14 feet and stripping from 1 to 5 feet. The rock composition is about average and the size considerably below.

Further south along Hannah's Creek a sufficient supply of gravel for the local need is obtained annually from the flood deposits. Among the main locations for obtaining this creek gravel are those in the central part of section 25, the northeast corner of section 35 (11 N., 2 W.), and the southeast corner of section 4 (10 N., 2 W.).

An abundant supply of good gravel is known to exist in the bluffs, terraces and flood plains of Whitewater River, but very few openings have been made, because of a good supply of creek gravel. Near Dunlapsville, on either side of the river, are small pits 50 feet above the river, in terraces. Both of these deposits were uncovered in grading the roads, and are almost certain to underlie several acres. The stripping ranges between ½ and 2 feet. The quality is exceptionally durable.

In the bluff of a tributary to Whitewater River, on the property belonging to C. N. Dawson, in the southwest quarter of section 18 (13 N., 14 E.), is a bed of gravel underlying an area of 30 by 150 yards, with a depth of 25 feet and a stripping varying between 2 and 3 feet. The quality, size and rock composition are about average.

About 4 acres, a little back from the bluff of the East Fork of Whitewater River, have been tested on the L. L. Bond place and are known to be underlain by gravel of a fair quality.

In a hill, which is situated 200 yards back from the bluff of the East Fork of Whitewater River on the Mrs. F. Williamson place, is a bed of gravel covered with a stripping of from 1 to 2½ feet. It has a depth of 9 feet, without any bottom being reached, and seems to underlie about 2 acres. The quality was the best seen by the writer in the county because of a very calcareous clay, which serves as a cement. This cement has so bound the material together in the bed that it comes out in great masses, which have to be blasted apart. When put on the road, the gravel is almost immediately cemented together, staying where it is placed, and producing a very smooth, hard and durable road.

In a brief summary of the gravel of the various civil townships, the writer will say that Harmony, Liberty and Brownsville townships are well supplied with gravel from the bluffs, terraces and flood plains of the East Fork of Whitewater River and its larger tributaries. A little gravel in Harrison Township is found along Silver Creek, but the main amount is shipped in from Richmond of Wayne County. The gravel of Center Township comes mainly from along Hannah's Creek and its larger tributaries. A small amount of an inferior quality is found in the bluffs of Four Mile Creek. No known workable deposits have been found in Union Township, and those that have been found contain a very poor quality of material.

LIMESTONE.

In the beds of the East Fork of Whitewater River and its larger tributaries are numerous outcrops of a blue limestone, which are probably the Cincinnati, all through the western part of the county. This stone is not needed as a road metal for the local use as long as there is such an abundant supply of gravel, and it is too soft for shipping.

FAYETTE COUNTY.

Area in square miles	215
Population in 1900	13,495
Miles of public roads	386
Miles of improved roads	270
Percentage of roads improved	70
Miles improved with gravel	270
Miles improved with crushed stone	None
Average original cost of gravel roads per mile*	$750
Total original cost of improved roads	$202,500
Authority	W. T. Murray, County Assessor

*All improved roads were built by the townships and the cost of $750 per mile is estimated.

Fayette County is located in the east central part of Indiana, being separated from the Ohio boundary by Union County. It lies south of Henry and Wayne, west of Union, north of Franklin and east of Rush counties.

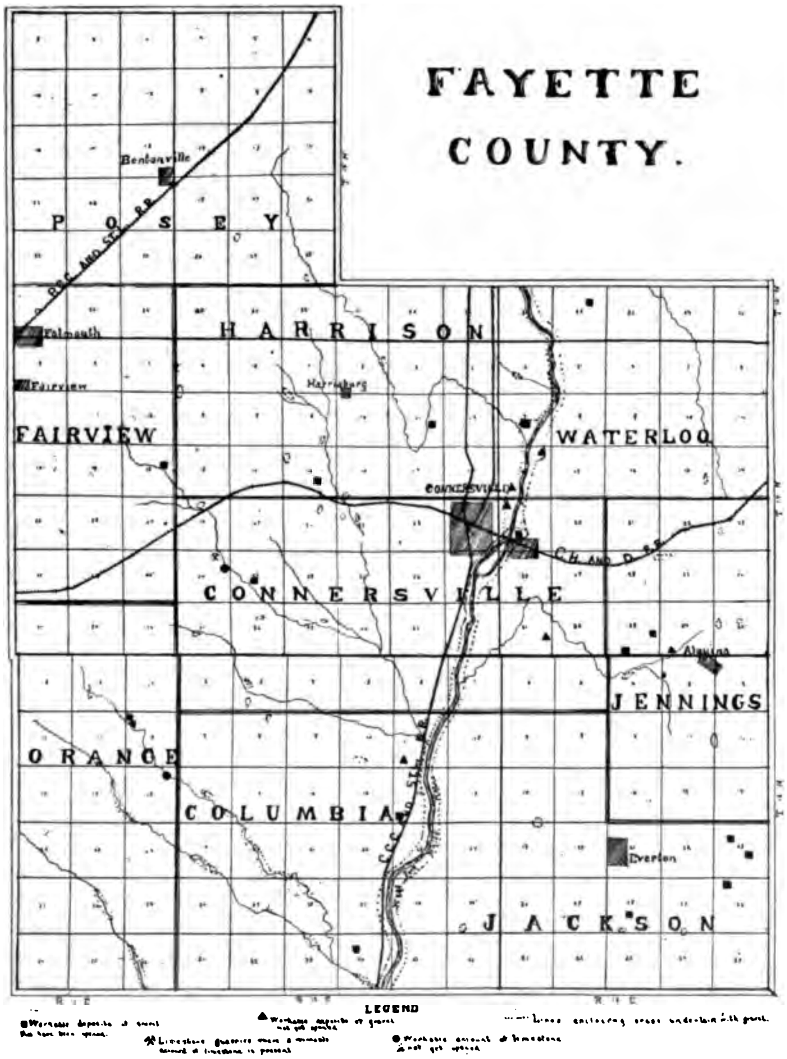

Fig. 31. Showing the distribution of road materials in Fayette County.

Three geological periods seem to be represented by the surface formations of this county. The Laurel limestone of the Silurian occurs in the stream beds of the western portion, the Cincinnati limestone of the Ordovician in the stream beds of the eastern part, and the later Wisconsin drift of the Pleistocene forms the surface covering of the entire county, with the exception of a small area on either side of the West Fork of Whitewater River, in the southern part. The surface is somewhat broken by the valleys of the West Fork of Whitewater River, which passes through the central part of the county from north to south, and its tributaries.

In quality, the material of this county for road building purposes, ranks among the better of central Indiana. Percentage averages of the size of the material are 8 clay, 17 fine medium sand, 12 medium sand, 19 coarse sand, 23 roofing pebble, 19 gravel and 2 boulder. The rock percentages are 83 limestone, 8 crystallines, 6 shale, 2 chert, and 1 slate. For amount of road building material, the county, with the exception of the northwest corner, is well supplied. The large deposits, where over a hundred thousand cubic yards are present, are located in the bluffs and terraces of the West Fork of Whitewater River, and a few of its larger tributaries in the southwestern part of the county.

The railway facilities are very good. The C., H. & D. and Big Four intersect at Connersville; the L. E. & W. runs north from Connersville, and a second division of the Big Four cuts the northwestern corner of the county. An interurban traction line is being built between Connersville and Rushville.

Gravel.

Township 15 North, Range 12 and Parts of 11 and 13 East.

This area comprises 44 square miles along the northern boundary of the county. With exception of along the West Fork of Whitewater River no good deposits are found in this township.

One-half acre has been tested on the land of C. Carver in the southeast quarter of section 28 (15 N., 12 E.), and is known to be underlain with gravel beneath from 3 to 6 feet of stripping. Most of the deposit is below the water level. The material, excepting fine sand, which would have to be screened off, is of an

average quality. Gravel is also known to occur beneath the ground-water level on the place of John Manlove in the northwest quarter of section 29.

Tests are said to show a good depth of gravel beneath water level in the flood plain of a small stream on the William Lamberson place in the southwest quarter of section 13 (15 N., 11 E.).

In the vicinity of the West Fork of Whitewater River almost all of the gravel is obtained from the annual flood deposits. A very large deposit of this nature is to be seen at the bridge in the southeast quarter of section 31 (15 N., 13. E.). At this place an area 300 by 700 yards is covered with gravel varying in size from that of a walnut to a large apple, and of a very durable quality.

An area of 100 by 100 yards is apparently underlain by gravel in the valley side of the West Fork of Whitewater River, on the D. Fiant place, in the northeast quarter of section 32. The bed has a known thickness of 25 feet and a stripping of from 1½ to 3 feet. The size and quality are a little above average.

Township 14 North, Range 12 and Parts of 11 and 13 East.

This township forms the central part of Fayette County and comprises the larger parts of the civil townships of Waterloo, Jennings, Harrison, Connersville and Fairview, and the northern edge of Orange.

An area of about 50 by 100 yards is underlain with gravel and fine sand in the southeast quarter of section 10 (14 N., 13 E.), on the farm of J. Sutliff. This deposit is covered with 3 feet of stripping and has a depth of 20 feet. The material is of about an average quality and size.

A deposit composed of ⅓ gravel and ⅔ fine sand is found outcropping for 300 yards along the bluff of a stream on the J. Miller property, in the northwest quarter of section 23 (14 N., 13 E.). The depth is 20 feet above water level and 4+ feet below.

Near the east central part of section 15 and the west central part of section 14 (14 N., 13 E.) are several acres that are known, by digging, to be more or less underlain by gravel.

On the property belonging to Mrs. Esther Larimore, in the northeast quarter of section 28 (14 N., 13 E.), is a bed of gravel and fine sand located in a low hill, with from 2 to 4 feet of strip-

ping and a depth of 13 feet. No bottom is found other than water. Tests of the following nature indicate a rectangle 100 by 100 yards to be underlain. The south wall of the pit shows an exposure of gravel 100 yards long, and a series of post holes extending parallel with the wall for 100 yards and 100 yards south of it are all in the gravel. A mean of two samples gives the average size and rock composition of the county. Five hundred cubic yards, at a cost of 5 cents each, are used in the annual building and repairing of the roads for 2 miles north, 1 mile east, 1 mile south and 1 mile west. These roads appear to be smooth and durable.

A similar deposit for size, rock composition, stripping and topographical position is found in the northwest quarter of section 27 (14 N., 13 E.), on the R. Riggs land. The depth ranges between 4 and 18 feet, and the extent is undetermined.

For about 200 yards along a stream bluff on the E. Conaway property, in the north central part of section 35 (14 N., 13 E.), groundhog diggings indicate a deposit of gravel of a very fair quality. In the southwest quarter of section 34, on the T. Lair farm, is a bed of gravel known, by plowing and other excavations, to underlie an area of 20 by 200 yards. The bed rests upon the limestone, has a depth of 12 feet and a stripping of from 1 to 3 feet. The size of the material and quality are a little below the average, and the rock percentages are 81 limestone, 6 crystallines, 10 shale, 1 slate and 2 chert.

A material of average size and quality is found in the bluff of a small stream on the property of H. Helvy, in the southeast quarter of section 33. The extent of the surface underlain by it is known to be 30 by 70 yards, the depth is 12 feet and the stripping from 4 to 5 feet.

In the east bluff of the West Fork of Whitewater River, and extending back for several hundred yards from the face, in the northeastern part of Connersville, are 45 acres which have been carefully tested by the C., H. & D. Ry. Co. and are known to be underlain by gravel. A section at the pit shows (a) stripping, 3 to 6 feet; (b) gravel a very little below the average for size, 5 feet; (c) gravel containing 20 per cent. roofing pebble and 5 per cent. gravel, 3½ feet; (d) sand, 1½ feet; (e) slump, 10 feet.

From 1,000 to 2,500 cubic yards of this material are taken out daily by means of a steam shovel and are used on the railroad for ballast. Immediately across the river from this pit a number of acres have been tested and are known to be underlain by gravel.

Another bluff deposit of this river is found on the J. Jones place, in the northeast corner of section 18 (14 N., 13 E.). This bed, underlying several acres, has a stripping ranging between 2 and 3 feet and a depth of 18+ feet. The quality and size of this material are a little above the average.

In the northeast quarter of section 7 (14 N., 13 E.), on the land belonging to George Ostheimer, is a bed of gravel showing along the bluff face for 150 feet. The depth of this deposit is 25 feet and the stripping 1½ feet. The size of the material and quality are a little above the average, and the rock percentages are 81 limestone, 9 crystallines, 7 shale, 2 chert and 1 slate. Very frequently this material grades into fine sand. As a road metal it is durable and gives good satisfaction.

In the bluff of the West Fork of Whitewater River, on the land of H. White, in the southwest quarter of section 6, is a bed of gravel having 1½ feet of stripping, a depth of 25 feet and a probable extent of 30 by 200 yards. The rock composition is about the average, but the size and quality of the material are a little above. Creek gravel of a good quality is also obtained from a small stream in the southwest quarter of section 6.

From Connersville on north to the county line the bluffs, terraces and flood plains of the West Fork of Whitewater River are almost continuous gravel beds. It is very probable that over a million cubic yards could be obtained along this stream. From the flood deposits alone several thousand cubic yards are obtained annually.

On the land of G. Holton, in the southeast quarter of section 11 (14 N., 12 E.), is a bed of gravel in the east bluffs of a tributary to the West Fork of Whitewater River, 50 feet above the stream and ¼ mile from it. The thickness of the bed is 18 feet, the stripping from 3 to 8 feet and the surface underlain with either gravel or fine sand at least 50 by 100 yards and probably much greater. The rock composition is about the average and the sizes are 5 per cent. clay, 20 per cent. fine medium sand, 5 per cent. medium sand, 15 per cent. coarse sand, 25 per cent. roofing peb-

Plate VII.

(a) The wall of the C., H. & D. Gravel Pit at Connersville.

(b) A nearer view of the wall of the C., H. & D. Gravel Pit at Connersville. A line of boulders is easily recognized near the top.

ble, 28 per cent. gravel and 2 per cent. boulder. This material ranks above the average for durability.

A gravel ranking decidedly above the average for wear on the road is found on the J. McCan farm, in the southwest quarter of section 4 (14 N., 12 E.), in the bluff of a stream. This deposit is workable, with a depth varying between 13 and 25 feet and a stripping of from 5 to 11 feet. The rock percentages are 80½ limestone, 10 crystallines, 5 chert, 4 shale and ½ slate, and the sizes are 9 per cent. clay, 10 per cent. fine medium sand, 3 per cent. medium sand, 12 per cent. coarse sand, 30 per cent. roofing pebble, 31 per cent. gravel and 5 per cent. boulder.

A medium size and quality of gravel is found in a creek bluff in the south central part of section 6, on the S. Shortridge property. This deposit rests upon a fine sand bottom, has a depth of 20 feet, a stripping of 3 feet and is probably workable. Gradations into fine sand and hardpan are common. This material is used in the building and repairing of the roads for 6 miles west, 4 miles north and 1 mile east.

Underlying several acres in the northwest quarter of section 16, on the J. C. Foster place, is a deposit of gravel with a depth of 25 feet and a stripping of 2 feet. The material is below the average in both size and quality, and the rock percentages are 80 limestone, 8 crystallines, 6 shale, 4 chert and 2 limonite. Hardpan and fine sand are often encountered in this deposit. In the bluff of a small stream in the northwest quarter of section 22, on the property of W. Moffatt, are probably 2 or 3 acres underlain by gravel.

On the land of J. N. Davis, in the southwest quarter of section 29 (14 N., 12 E.), is a deposit of gravel with a depth of 40 feet and a stripping of 1 foot. The surface underlain is known to be at least 60 by 80 yards. A section shows: (a) soil, 1 foot; (b) material composed of 40 per cent. clay, 40 per cent. boulder and 20 per cent. gravel, 8 feet; (c) a coarse gravel containing 20 per cent. of a very calcareous clay, 13 feet; (d) boulder and calcareous clay, 2 feet; (e) material of average size, which comes out in great masses so thoroughly cemented by a calcareous clay that they have to be blasted apart, 13 feet. Because of this cement this gravel makes a hard, smooth and very durable road. A bed of gravel is

reported on the Lockhart and Griffith farms, in the northeast quarter of section 32 (14 N., 12 E.).

Extending for about 200 yards in a low stream bed in the northwest quarter of section 31, on the farm of the Michener heirs, is a bed of gravel with a depth where tested of 8 feet. A material a little below the average for size is also found in a stream bluff on the land of W. C. Moffatt, in the northeast quarter of section 19 (14 N., 12 E.). The stripping is 2 feet, the depth 10 feet and the area underlain is about 1 acre.

A rather fine material is also found in the northeast quarter of section 13 (14 N., 11 E.), on the B. Carr place. The depth of this deposit is 20 feet, the stripping 6 feet and the extent of the surface underlain about 60 by 70 yards. The rock percentages are 79 limestone, 11 crystallines, 6 shale and 4 chert. This is the only known deposit of economic importance in the civil township of Fairview.

Township 13 North, Range 12 and Parts of 11 and 13 East.

This area of 84 square miles occupies the southern part of the county and contains the civil townships of Orange, Columbia, Jackson and parts of Connersville and Jennings.

Numerous locations are found in the stream bluffs and terraces of the southern halves of Orange and Columbia townships, but very few have been opened because of the large supply of creek gravel. This creek gravel is very little oxidized, and consequently durable, but its slowness in packing makes it rather unsatisfactory. In the northern half of these two the gravel is obtained from the bluffs and terraces of streams. Along a tributary to the West Fork of Whitewater River there are pits opened in the bluffs on the farms of A. Pike, in the northwest quarter of section 2, I. Daly, in the southwest quarter of section 2, J. Gray, in the southwest corner of section 1, H. Hadley, in the northwest corner of section 12, and in the terraces on the farms of W. Tate, in the northwest quarter of section 18, and H. Jones, in the southeast quarter of section 18 (13 N., 11 E.).

The deposit of the Gray and Hadley places has a depth of 13 feet and no bottom reached, a stripping of 2 feet and underlies a sur-

face of 30 by 270 yards. The quality of the material is above the average, the sizes being 5 per cent. clay, 13 per cent. fine medium sand, 7 per cent. medium sand, 25 per cent. coarse sand, 25 per cent. roofing pebble, 24 per cent. gravel and 1 per cent. boulder; and the rock percentages 80 limestone, 8 shale, 7 crystallines, 4 chert and 1 slate. A similar gravel for quality is found exposed in the stream bluff 1/4 of a mile southeast of this deposit. Here the exposure, which has been developed by the stream cutting on the north bank and producing a slumping, is 100 yards long and 35 feet from the bottom to the top. A number of places are reported in this immediate neighborhood where the gravel underlies the surface.

On the W. Tate property the deposit seems to be workable. It has a stripping of 2 feet and a depth of 10 feet without any bottom being reached. For quality and size this material is above the average. The Jones deposit is similar in quality and has a depth of 12 feet and a stripping of 2 feet. The extent is undetermined.

A bed composed of 1/2 gravel and 1/2 fine sand is located on the Murphy farm, in the southwest quarter of section 5 (13 N., 12 E.). The thickness of this deposit is 8 feet and the stripping 2 feet. The rock composition and size of material are about average.

Although large amounts of gravel are known to be present in the bluffs, terraces and flood plains of the West Fork of Whitewater River, very few pits have been opened because of the abundant supply furnished by the annual floods. Small pits have been opened in the west bluff on the Conica heirs' place, in the southwest corner of section 14, and on that of Thomas Wright, in the southwest corner of section 11 (13 N., 12 E.). The former is known to be present in the bluff for 200 yards and to have a stripping of 1/2 to 2 feet. It has been worked to a depth of 17 feet without reaching the bottom. The rock composition and size of the material are about average. The latter has been found to follow the bluff for 150 yards, to be under from 1 to 5 feet of stripping and to be similar to the former in quality.

Advancing eastward from the West Fork of Whitewater River we find no known workable deposits until we reach the eastern half of the civil township of Jackson. Here we find on the land be-

Plate VIII.

(a) An abrupt change from gravel to clay in the C., H. & D. Pit at Connersville. The clay can be recognized by its furrowed character.

(b) Gravel deposit at the junction of the East and West Forks of the Whitewater River near Brookville.
Illustrating the deposition of gravel by the retarded current as it turns from the channel to the flood plain.

longing to A. Backhouse, in the southwest quarter of section 28 (13 N., 13 E.), a location in a hill which is situated in the center of a valley. This hill, which has been found by a number of tests to be composed of gravel, is 100 yards long, 60 yards wide and 6 yards high.

In a stream bluff several hundred yards northeast of the Backhouse deposit and in the same quarter section is a bed of gravel, fine sand and clay on the place of W. Wildaridge. This bed is known to follow the bluff for 250 yards, to have a depth of 20 feet and a stripping ranging between 1 and 4 feet. The quality of this material, excepting the clay and fine sand, which compose fully half of the deposit, is about the average. A gravel a little above average in size and quality is known to underlie the surface on the C. Mahle place, in the southeast quarter of section 27 (13 N., 13 E.).

Underlying a surface of 70 by 200 yards in the northwest quarter of section 26, on the land of C. Blackburn, is a bed of gravel, resting upon a clay bottom, with a depth of 14 feet and a stripping of 2½ feet. The average of 2 samples gives the following sizes: 7 per cent. clay, 7 per cent. fine medium sand, 10 per cent. medium sand, 25 per cent. coarse sand, 25 per cent. roofing pebble, 25 per cent. gravel and 1 per cent. boulder. The rock composition is about the average.

At least 4 or 5 acres are underlain with a gravel similar in quality to the Blackburn, on the S. Cockafair farm, in the southeast quarter of section 23 (13 N., 13 E.). This bed is located in a stream bluff, rests upon a clay bottom, has a depth of 18 feet and a stripping ranging between ⅓ and 2 feet.

In the northwest quarter of section 23, on the land of A. T. Becket, is a bed of gravel, which is known to be present in a stream bluff for 300 yards and to extend back from its face in places for 50 feet. This bed rests upon a clay bottom, has a thickness of 18 feet and a stripping of 2½ feet. The rock composition is about average and the size a little below. Gradations into fine sand and clay are common.

On the property belonging to Mrs. Alice Jackson and the adjacent farm to the west are a number of small deposits of gravel which occur in the bluff of a small stream for about ½ mile.

Where they have been opened they are found to contain a rather fine quality of gravel, to have a depth of about 10 feet and a stripping of from 2 to 4 feet.

LIMESTONE.

Numerous outcrops of what is probably the Laurel limestone occur in the beds of streams in western Fayette County. The stone is hard and has a bluish color. A sample was obtained from a stream bed where stone was being taken out for ballast for the interurban line being built between Connersville and Rushville, in the east central part of section 30 (14 N., 12 E.), on the farm of J. Ochiltree. The depth of the deposit at this place is known to be 12 feet, and the beds vary between ½ and 3 feet in thickness.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of Laurel Limestone from the James Ochiltree Farm.**

Specific gravity	2.7	French coefficient of wear	14.8
Weight per cu. ft. (lbs.)	168.4	Hardness	—5.3
Water absorbed per cu. ft. (lbs.)	2.18	Toughness	6
Per cent. of wear	2.7	Cementing value—Dry	34
		Wet	65

"A rather soft limestone, rather low in toughness, with fairly high resistance to wear and fair cementing value. Best suited to highway and country-road traffic."—Page.

A chemical analysis by the chemist at the Road Testing Laboratory shows the composition of the limestone to be as follows:

Chemical Analysis of Laurel Limestone from the James Ochiltree Farm.

	Per cent.
Alumina (Al_2O_3)	2.01
Iron oxide (Fe_2O_3)	.76
Lime (CaO)	37.10
Magnesia (MgO)	7.67
Insoluble in hydrochloric acid	15.04
Loss on ignition	36.49
Total	100.20

"Sample is unusually rich in phosphoric acid. The insoluble portion is clay."

*For standard of comparison see p. 79.

FRANKLIN COUNTY.

Area in square miles	394
Population in 1900	16,388
Miles of public roads	1,000
Miles of improved roads	143
Percentage of roads improved	14.3
Miles improved with gravel	143
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$2,000
Total original cost of improved roads	$286,000
Annual cost of repairs per mile on gravel roads 5 years old	$65
Proportion of improved roads built since 1895 (per cent.)	80
Satisfaction of farmers with investment in improved roads	Good
Authority	Chas. A. Miller, County Auditor

Franklin County is situated on the east border of the State, south of Union and Fayette, west of Rush and Decatur and north of Dearborn and Ripley counties. The topography of this county is that of a plain cut to a depth ranging between 300 and 400 feet by the larger streams. The East Fork of Whitewater River with the main Whitewater River traverse diagonally across the central part of the county from the northwest to the southeast. The East Fork passes about due north from where it empties into the main stream at Brookville.

The surface rocks of this county belong to three geological periods. The soft, blue limestone, which outcrops in all of the deeper valleys, is the Cincinnati stone and belongs to the Ordovician. The Laurel limestone, which is found outcropping in the hilltops west of Laurel and north of Brookville, belongs to the Silurian period. The drift of the later ice invasion, which occupies the northeastern part of the county and touches the northwest corner, and the older drift, which covers the greater part of the county and has for its surface a deposit of white clay several feet in thickness, belong to the Pleistocene period.

With the exception of 2 or 3 deposits, the only ones of economic importance are found in the bluffs, terraces and flood plains of the East and West Forks of Whitewater River and the main stream below their union. Of these the terrace deposits are the main sources of supply at present. Large quantities of gravel are also obtained from the annual flood deposits.

For little weathering and size of material, with exception of

FRANKLIN COUNTY.

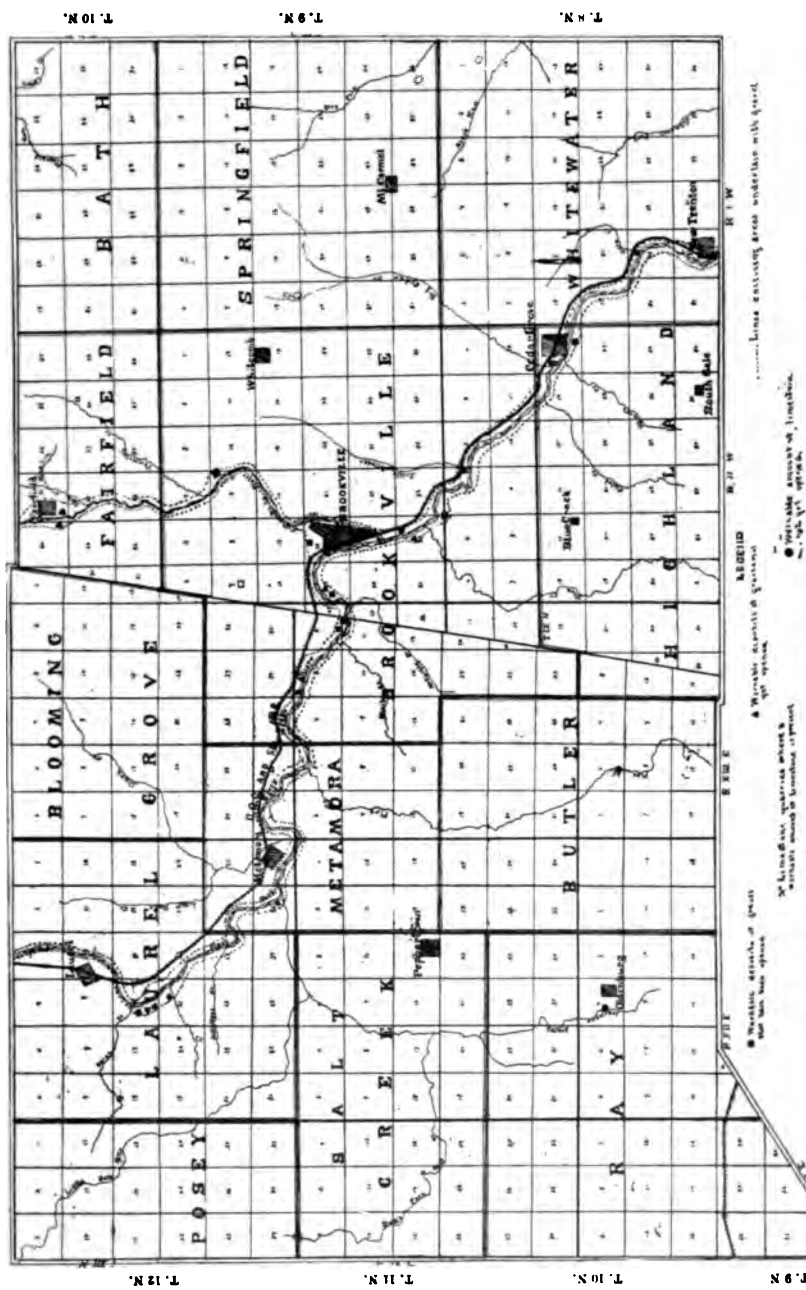

Fig. 32. Showing the distribution of road materials in Franklin County.

the clay being very low, the quality of the gravel of this county will rank among the first of central Indiana. The average sizes of the material are 2 per cent. clay, 6 per cent. fine medium sand, 4 per cent. medium sand, 14 per cent. coarse sand, 27 per cent. roofing pebble, 42 per cent. gravel and 5 per cent. boulder, and the rock percentages are 80 limestone, 13 crystallines, 3.5 shale, .5 sandstone and slate and 3 chert.

The transportation facilities are very meager, one division of the Big Four, which follows the valley of the West Fork of Whitewater River and the main stream, being the only railroad.

Gravel.

Township 12 North, Ranges 12, 13 and Part of 11 East; and the Southern Three Miles of Township 10 and the Northern Three Miles of Township 9 North, Range 1 and Part of 2 West.

This area of 156 square miles comprises the northern 2-5 of the county and contains the civil townships of Bath, Fairfield, Blooming Grove, Laurel, Posey and the northern parts of Metamora, Brookville and Springfield.

East of the East Fork of Whitewater River the practicable deposits are found along Indian, Big Cedar and Templeton's Creek, and in morainic hills in the west central part of the civil township of Springfield. These morainic deposits are found in the southeast quarter of section 18 (9 N., 1 W), on the farms of Mrs. Mary Elwell and P. M. Elwell. They underlie about 1 acre, rest upon clay bottoms, are beneath from ½ to 3 feet of surface and have average depths of about 12 feet. The rock percentages are 85 limestone, 9 crystallines and 6 shale, and the sizes of the material are 8 per cent. clay, 10 per cent. fine medium sand, 12 per cent. medium sand, 30 per cent. coarse sand, 30 per cent. roofing pebble, 9 per cent. gravel and 1 per cent. boulder. This material, because of its inferior quality and limited amount, should be used only in the immediate neighborhood.

A surface of 100 by 300 yards in the north central part of section 26 (10 N., 2 W.), on the Beesley heirs' property, in the valley side of Templeton's Creek, has received scattered tests. It is found to be underlain by gravel, fine sand and clay, which grade

(a) Gravel bar at junction of Forks of Whitewater near Brookville.
Illustrating the assorting power of the currents, which become more and more retarded, as they advance onto the flood plain. At the water level the material is very coarse, but becomes finer as it gets farther from the stream.

(b) A nearer view of the above.
Illustrating decrease in coarseness of the gravel as one advances from the stream.

into one another. The deposit has been worked to a depth of 8 feet without reaching the bottom, and the stripping varies between ½ and 3 feet. The quality is not as good as that along the East Fork of Whitewater, the sizes being much smaller and the oxidation higher. The rock percentages are 88 limestone, 5 crystallines, 5 shale and 2 limonite. This material is used in building and repairing for 4 miles east and 1 mile south.

As already mentioned, the terraces and flood plain of Whitewater River are almost continuous beds of gravel and fine sand, now and then grading abruptly into clay. The present supply for the building and repairing of roads comes from the annual flood deposits and small pits in the terraces. Pits of the second terrace above the flood plain are found on the places of W. Armstrong, in the southwest quarter of section 21, and Mrs. P. M. Cory, in the northwest corner of section 28 (10 N., 2 W.).

Both the Armstrong and Cory deposits are known to be far better than workable. No bottom has been found to either, and the size of the material is above the average. The rock composition is about average. The surface overlying the former is from two inches to 3 feet and the latter from two inches to 1 foot. The former has been worked to a depth of 12 feet and the latter 6 feet. Wells in the town of Fairfield, where these pits are located, are almost all in a good quality of gravel.

A gravel pit in the first terrace of this river is found on the land belonging to Bert Logan, in the northeast quarter of section 9 (9 N., 2 W.). This deposit is known to have an extent of at least 40 by 100 yards and a stripping ranging between 1-6 and 4 feet. It has been worked in places to a depth of 25 feet and no bottom has been reached. The quality of this material is very good, the size being about the average, except the amount of clay, about 8 per cent., which causes it to pack well. The rock percentages are 75 limestone, 11 crystallines, 5 chert, 5 shale and 4 limonite.

In a morainic hill which stands 45 feet above the adjacent region, in the central part of section 7 (9 N., 2 W.), on land belonging to the county, is a bed of gravel underlying 1½ acres, with a stripping of from 3 to 6 feet and a depth of 25 feet. No bottom has been found. The sizes of the material are 17 per cent. clay, 3 per cent. fine medium sand, 1 per cent. medium sand, 5 per cent.

coarse sand, 12 per cent. roofing pebble, 50 per cent. gravel and 12 per cent. boulder, and the rock composition is about the average. Although the gravel in places merges somewhat into clay and fine sand, it is of a good quality. The high percentage of clay makes the roads built by it a little more muddy than the average, but the quickness in packing and the remaining on the roads makes it a very desirable material.

Advancing westward from this deposit no other of economic importance is known until the valley of the West Fork of Whitewater River is reached; and this, like the East Fork, has almost continuous beds of gravel in its terraces and flood plains. Its flood deposits, because of their accessibility, furnish the larger part of the gravel used on the roads. On the first terrace openings have been made on the places of the Williams heirs, in the northwest quarter of section 16, Masters, in the west central part of section 16, and G. Hunsenner, in the north central part of section 21 (12 N., 12 E.).

All of these deposits are known to be workable, and the bottoms have been found to none. The Williams has been worked to a depth of 10 feet, and contains from three inches to 2 feet of stripping. The sizes are .5 per cent. clay, 1.5 per cent. fine medium sand, 7 per cent. medium sand, 18 per cent. coarse sand, 23 per cent. roofing pebble, 45 per cent. gravel and 5 per cent. boulder. The rock percentages are 75 limestone, 18 crystallines, 4 chert, 2 shale and 1 sandstone. The low per cent. of clay causes great slowness in packing. The Masters deposit is beneath ½ foot of surface and has been worked to a depth of 14 feet. The sizes are a little below the average, with .5 per cent. clay, and the rock composition similar to the Williams. The Lockwood deposit has been worked to a depth of 6 feet and has no stripping. The material is rather small for size and the amount of clay very low. The rock percentages are 91 limestone, 7 crystallines, 1 chert and 1 shale.

For about 100 yards in the banks of a small stream in the southwest quarter of section 18 (12 N., 12 E.), on the land of E. Fey, is a bed of gravel which has been exposed by groundhog diggings. The depth is known to be 13 feet and the stripping from 2 to 6 feet.

A residual gravel is obtained from a creek bed near the south central part of section 34 (12 N., 11 E.), and the north central part of section 3 (11 N., 11 E.). It is made up of 35 per cent. limestone, 30 per cent. sandy shale, 25 per cent. argillaceous chert and 10 per cent. quartz.

All of the civil townships of this congressional township contain from 50 to 75 per cent. of improved roads, with the exception of Posey, which has only ½ mile, and the western half of Laurel.

Township 11 and Part of 10 North, Ranges 12 and Parts of 11 and 13 East; and Townships 8 and 9 North, Ranges 1, 2 and Part of 3 West.

This area of 284 square miles makes up the southern 3-5 of the county and comprises the civil townships of Ray, Salt Creek, Butler, Highland, Whitewater and parts of Metamora, Brookville and Springfield. With the exception of some fragmental pieces of residual material collected in the stream beds from the bed rock, no gravel deposits are found west of the West Fork of Whitewater and the main river.

A considerable amount of this residual material is found in the northwest quarter of section 4 (11 N., 12 E.), in the bed of a tributary to the West Fork of Whitewater. It is composed of 54 per cent. limestone, 20 per cent. shale, 15 per cent. argillaceous chert and 11 per cent. crystallines. Where it is found in Pipe Creek at Heimond, in Blue Creek between Highland Center and St. Peters and in numerous other places of these parts it is composed entirely of fragments of a soft, shaly, blue limestone which probably belongs to the Cincinnati group. The fragments that are put on the road vary from ½ to 6 inches across.

Both the flood plains and terraces of the West Fork and Whitewater River proper contain large quantities of gravel in all of the sections. As in the vicinity of the river in the other congressional township, the greater part of the gravel is obtained from the flood deposits. Terrace deposits have been opened on the places of D. Hawkins, in the northwest quarter of section 3; H. Kimball, in the north central part of section 2; Mrs. L. Trageser, in the southeast quarter of section 2; J. S. Martin, in the north central part of section 11 (11 N., 13 E); H. Stoops, in the southwest quarter of

section 19; H. Grimme, in the northwest quarter of section 32 (9 N., 2 W.); J. Fohl, in the central part of section 13; J. Wilhelm, in the southeast quarter of section 13 (8 N., 2 W.), and J. Rudicil, in the northeast quarter of section 29 (8 N., 1 W.). Very good exposures are found in the side of the terrace near the junction of Little Cedar and Richland creeks with Whitewater river.

The Hawkins, Kimball and Trageser deposits are all much better than workable, are beneath from ½ to 2 feet of surface and have been worked to depths of about 7 feet. No bottoms have been found. The sizes of the material are .5 per cent. clay, 3.5 per cent. fine medium sand, 2 per cent. medium sand, 14 per cent. coarse sand, 30 per cent. roofing pebble, 47 per cent. gravel and 3 per cent. boulder. The color is gray and the oxidation is very low. The selling price at the pits is 5 cents per cubic yard. This material is very durable, but packs slowly because of no clay.

The Martin deposit is similar to these deposits, with exception of having been worked to a depth of 12 feet and having a tested extent of 45 by 250 yards. It occurs on a spur, which is a remnant of the first terrace, extending out from the bluff. Another similar deposit is the Stoops, except that it occurs on the second terrace above the flood plain instead of the first and has a known extent of 50 by 250 yards.

The Grimme pit is found in the second terrace above the flood plain. It shows a depth of 7 feet and from ½ to 3 feet of stripping. No bottom has been found. The extent of the deposit is known to be for 300 yards along the terrace front. The sizes of the material are about average and the rock percentages are 75 limestone, 11 crystallines, 5 chert, 5 shale and 4 limonite.

The Fohl bed occurs in the first terrace beneath from ¼ to 6 feet of surface, and has been worked to a depth of 20 feet without any bottom being reached. The extent is at least 50 by 150 yards. The rock composition is about the average and the sizes are 4 per cent. clay, 12 per cent. fine medium sand, 5 per cent. medium sand, 35 per cent. coarse sand, 30 per cent. roofing pebble, 12 per cent. gravel and 2 per cent. boulder. The Wilhelm pit, cellars and dug wells of Cedar Grove show a similar quality of gravel. The material of the Rudicil pit is reported to be a little coarser.

In the northern part of Brookville, on the lots of W. Smeister, is a workable bed of average size gravel in the front of the third terrace above the flood plain.

East of Whitewater River there are no workable deposits; but some small sandy ones are found on the places of M. Hayes, in the south central part of section 1, and J. Stevens, in the west central part of section 36 (8 N., 1 W.). Some road-building material is obtained from the flood deposits of Johnson's Fork.

LIMESTONE.

In almost every part of this county the soft, blue and often shaly Cincinnati limestone occurs in the stream beds. At a number of places in Harper's Branch, Cedar Fork, Pipe and Blue creeks broken fragments of this stone have accumulated on the stream beds. These fragments are generally thin, much oxidized and more or less shaly. When put on the road they break up quickly and make a road which soon becomes rutty. If taken in the unweathered conditions and free from shale this stone will probably give very fair satisfaction. Because of the abundant outcrops, a small portable stone crusher could be set in almost any vicinity where a road material is needed. Since the transportation facilities are very poor this would undoubtedly be the most economical way of obtaining a road metal.

What seems to be a very fair quality of limestone for macadam is found at the J. P. Secrest quarry a couple of miles west of Laurel. This is the Laurel limestone. It is hard and varies in color between a gray and blue. A large quantity of this stone is found in the vicinity of this quarry. It also is quarried in the west central part of section 13 on the Wilhelm place.

About three miles southwest of Laurel an important quarry has been opened at Derbyshire Falls. Here ten layers of Laurel limestone ranging in thickness from two and a half to six inches and aggregating four feet two inches are exposed beneath two feet of stripping. This stone is quite hard and durable, and will make a good quality of macadam material. A spur of the Big Four Railway has been built to the quarry, so that transportation facilities are good.

RUSH COUNTY.

Area in square miles	406
Population in 1900	20,148
Miles of public roads	1,100
Miles of improved roads	550
Percentage of roads improved	50
Miles improved with gravel*	540.75
Miles improved with crushed stone	9.25
Average original cost of gravel roads per mile**	$1,500
Average original cost of stone roads per mile	$3,000
Total original cost of improved roads	$539,100
Annual cost of repairs on gravel roads 5 years old	$150
First improved roads built	1866
Proportion of improved roads built since 1895 (per cent.)	10
Satisfaction of farmers with investment in improved roads	Good
Authority	A. L. Stewart, Ex-County Surveyor

*Includes 400 miles of gravel roads built by the townships at an estimated average cost of $750 per mile.

**Average cost of 140.9 miles built under contract by sale of bonds.

This county lies west of Fayette and Franklin, north of Decatur, east of Shelby and Hancock, and south of Henry and Hancock. It has the form of a rectangle with a width from east to west of 18 miles and a length from north to south of 23 miles.

Three geological periods are represented by the outcropping rocks of this county. The *Laurel limestone and Waldron clay, which outcrop 200 yards above the bridge in the Big Flatrock Creek at Moscow and 40 yards below the bridge in Little Flatrock Creek at Milroy, belong to the Niagara. Going up stream from this outcrop at Moscow, "the Laurel limestone soon passes below drainage and the Devonian limestone occurs in the bed of the creek." The drift, which covers the entire county to a depth on an average of 100 feet, belongs to the earlier and later invasions of the Wisconsin ice sheet, which is of the Pleistocene period.

The topography of this county is that of a gently undulating plain, with a small moraine crossing its southeast corner and another traversing its western half from north to south.

The large deposits of gravel, from which 100,000 cubic yards might be obtained, are found in the terraces and flood plains of Big Blue River, Big Flatrock Creek and a morainic ridge in the southeastern part of the civil township of Union. Small but still

*Twenty-fourth Ann. Rep. Ind. Geol. Surv., pages 139 and 140.

RUSH COUNTY.

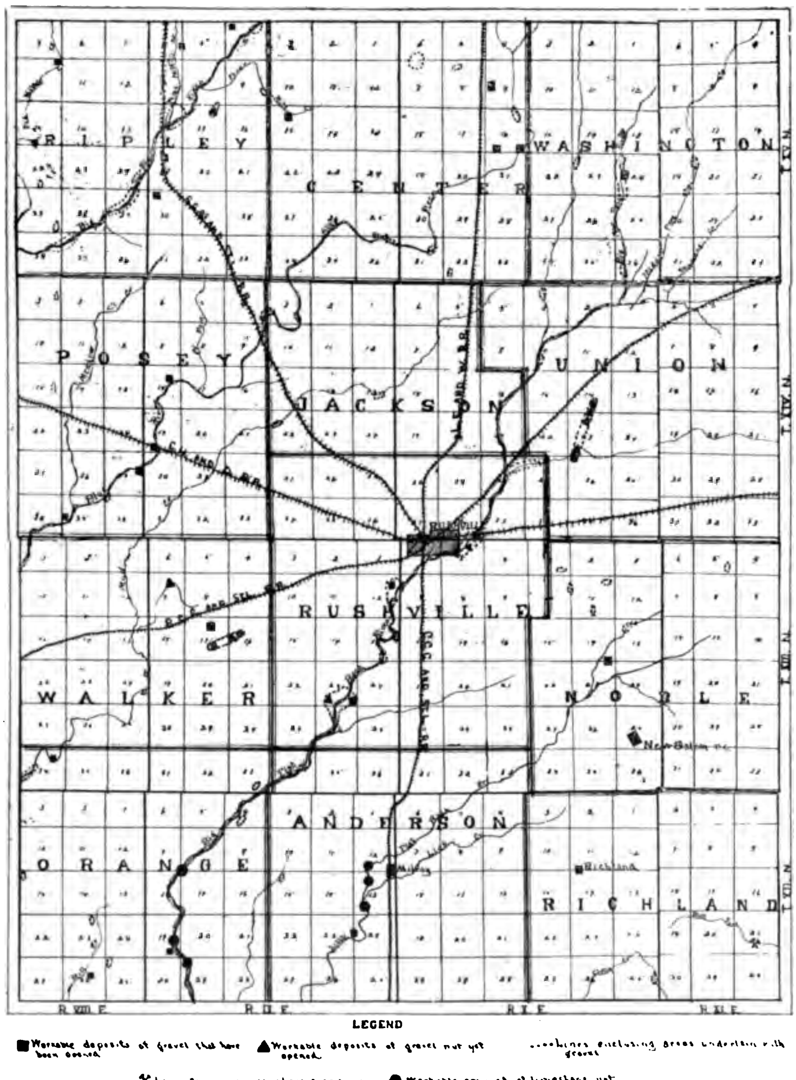

Fig. 33. Showing the distribution of road materials in Rush County.

workable deposits are found in the bluffs, terraces and flood plains of Six Mile, Three Mile, Shankitunk, Mud and Little Flatrock creeks, in Little Blue River and in morainic hills and ridges in the eastern part of the civil township of Walker and the northern part of Center. For amount and quality of gravel Rush County stands among the first of central Indiana. The average sizes of the material for the county are 8.5 per cent. clay, 16.5 per cent. fine medium sand, 13 per cent. medium sand, 18 per cent. coarse sand, 24 per cent. roofing pebble, 18 per cent. gravel and 2 per cent. boulder; and the rock percentages are 78 limestone, 11 crystallines, 6.5 shale, 2 slate, 2 chert and .5 sandstone.

The railway facilities are splendid. Intersecting at Rushville, the county seat, and radiating in all directions are the Ft. Wayne, Cincinnati and Louisville, the Cincinnati, Hamilton and Dayton, the Michigan division of the Big Four and the Columbus and Cambridge City branch of the Pennsylvania.

GRAVEL.

Township 15 North, Ranges 9, 10 and Parts of 8 and 11 East.

This area of 108 square miles comprises the northern fourth of the county. In it are found the civil townships of Ripley, Center and Washington. Ninety per cent. of the roads of the first are graveled, 84 per cent. of the second and 85 per cent. of the last.

This area, with the exception of the southeast corner, the northeast boundary and a few square miles in the central part, is very well supplied with gravel for road purposes. The principal deposits are located in the flood plains, terraces and bluffs of the larger streams, and in some kames in the northern part of the civil township of Center.

Some very fair deposits are found in the bluffs and terraces of Six Mile Creek. Among these are bluff deposits on the E. Hunt place, in the south central part of section 15, and on that of R. Harter, in the northeast corner of section 10, and a terrace deposit on the J. Moore land, in the northwest corner of section 11 (15 N., 8 E.).

On the Hunt farm about 2½ acres have been roughly tested and seem to be underlain with a good quality of gravel. The depth of the deposit at the pit is 15 feet without any bottom other

than water being reached, and the stripping is 6 feet. The quality for road building, because of size and little oxidation, is considerably above the average for a material above the ground-water level.

On the Harter place 4 or 5 acres are known, by several pit openings and some scattered tests, to be underlain by gravel and fine sand. At the pits the depth is 9 feet without any bottom being found, stripping 1½ feet and size of material, rock composition and amount of weathering about average. The Moore, with a similar stripping, depth and quality of material, underlies about 2 acres.

Although a large amount of gravel is known to occur in the bluffs and terraces of Three Mile Creek, only two pits have been opened. These are on the C. Estes property, in the southeast corner of section 6, and that of C. Hill, in the northeast corner of section 7 (15 N., 9 E.). Both deposits occur in the bluff and are rather similar in quality, the size of the material and rock percentages being about the average. The Estes deposit is from 7 to 20 feet deep and is known by rough tests to underlie 60 by 100 yards of surface. The stripping ranges between 2 and 6 feet.

The flood plains, terraces and bluffs of Big Blue River contain abundance of gravel to supply the local need for years to come. Because of availability, deposits have only been opened in the bluffs and terraces. In the bluffs we find openings on the James Forbis place, in the northeast quarter of section 34; the H. Adams, in the northwest quarter of section 35; the Clark, in the northeast quarter of section 26 (15 N., 8 E.); the J. Newby, in the northwest quarter of section 30; the T. Moore, in the south central part of section 24; the H. Phelps, in the south central part of section 24; the Benford, in the northeast quarter of section 19, and other places near the central part of section 18 and the northeast corner of section 4 (15 N., 9 E.).

The Adams pit is known to underlie 20 by 150 yards, to have a depth of 10 feet without any bottom being reached and a stripping of 1 foot. The rock percentages are about average, and the sizes of the material at the pit are 5 per cent. clay, 8 per cent. fine medium sand, 2 per cent. medium sand, 3 per cent. coarse sand, 15 per cent. roofing pebble, 60 per cent. gravel and 7 per cent. boulder.

In a bluff standing 50 feet above the terraces of Blue River is the deposit on the Newby farm. At the pit there is from 2 to 5 feet of stripping, a depth of 12 feet and a workable extent. Both the size of the material and rock composition are about the average. A rather undesirable material is that found at the Moore pit, being made up of 25 per cent. boulders and 45 per cent. fine sand. The Phelps bed is workable and contains material of average quality.

Five or six acres, by scattered tests, are claimed to be underlain on the Benford place, which seems to be a remnant of an old terrace. The depth of the bed is 12 feet and the stripping from 1 to 3 feet. The size of the material is a little above the average.

In Carthage the wells in general and many of the cellars are in the gravel. The gravel is also often reached in grading.

A material somewhat above the average in sizes is found on the V. A. Heaton and J. E. Sims farms, in the northwest corner of section 4 (15 N., 9 E.). The depth to ground-water level, beneath which no tests have been made, is 12 feet, and the surface underlain is 100 by 100 yards. The stripping ranges between ½ and 1 foot. As a road material this gravel is of about an average quality.

In what appears to be a remnant of the second terrace above the flood plain of Blue River is a bed of gravel and fine sand on the O. W. Righter property, in the northeast quarter of section 17 (15 N., 9 E.). This deposit, by a couple of pits and other excavations, seems to underlie the entire remnant, which would give a length of 400 yards and a width of 30 yards. The depth at a pit is 11 feet to ground-water level, below which the material has not been taken out. The stripping varies between 1 and 4 feet. The size of material and quality are about average.

On the property belonging to A. Ruby, in the northwest quarter of section 15 (15 N., 9 E.), is a bed of gravel in the bluff of Three Mile Creek which shows the following sections: (a) stripping, 2½ feet; (b) fine gravel and fine sand interstratified, 6½ feet; (c) gravel much above the average for size, 3½ feet; (d) hardpan, 4 feet; (e) gravel a little above the average for size, 9 feet. The rock percentages are 73 limestone, 13 crystallines, 5 shale, 4 chert, 2 slate and 3 sandstone. The area underlain, as has been learned by plowing and post auger holes, is 100 by 150 yards. Other

small deposits are found in the bluff of this stream on the O. Sears farm, in the southeast corner of section 9 (15 N., 9 E.), and on the W. Hull place, in the northeast quarter of the same section.

In a morainic deposit on the farms of W. Cross, in the southwest quarter of section 6 and the northwest corner of section 7 (15 N., 10 E.), are several acres underlain by gravel and fine sand, as has been learned through 2 pit openings, a few post auger holes and other excavations. At the pits the depth is about 17 feet and the stripping from 4 to 5 feet. The sizes of the material and rock percentages are about average. Where used on the roads this material has given good satisfaction.

In a kame, which stands out very conspicuously above the adjacent region, is a bed of gravel underlying about 1/2 acre on the Newhouse land, in the northwest quarter of section 8. The depth of the deposit is from 5 to 17 feet and the stripping 2 1/2 feet. The sizes of the material are about the average for the county.

On the farm of Mrs. Ellen English, in the southwest quarter of section 9, 4 or 5 acres of a kame, which is 35 feet high, have been tested and are known to be underlain by gravel. This bed of gravel rests on a clay bottom, is from 14 to 30 feet thick and has a stripping of from 1 to 4 feet. An average of three samples gives the following sizes: 12 per cent. clay, 25 per cent. fine medium sand, 9 per cent. medium sand, 8 per cent. coarse sand, 27 per cent. roofing pebble, 17 per cent. gravel and 2 per cent. boulder, and the rock percentages are about the average. The amount of clay makes this gravel pack quickly and keeps the particles from rubbing against one another, thus giving a hard and durable road.

In a kame which rises 50 feet above the adjacent country is a deposit of 4-5 fine sand and clay and 1-5 gravel underlying about 15 acres, as learned through three pits and other openings, on the land belonging to G. Coulter, in the southwest quarter of section 16 (15 N., 10 E.). The gravel occurs as irregular masses in the clay and fine sand.

About 2 acres are known to be more or less underlain by gravel and fine sand, and one location has been found for setting a gravel excavator in the southwest quarter of section 32 (15 N., 10 E.), on the J. Ward property. The bed rests upon a clay bottom, has

a depth where tested ranging between 10 and 15 feet and a stripping between 1 and 5 feet.

All along Little Blue River farmers report the flood plains to be underlain by gravel, but only at a few places have they been opened. Among the deposits opened along this stream are those in the flood plains on the N. Jones and H. Gibson places, in the northeast quarter of section 36 (15 N., 9 E.); the W. Hamilton place, in the east central part of section 31 and west central part of section 32, and along the valley side and in the flood plain in the southeast quarter of section 16 (15 N., 10 E.), on the Bell property.

The flood plain deposits, which are below ground-water level, on the Jones and Gibson places are said to have been found to underlie Little Blue River for 400 yards. On the former place the deposit is 6 feet deep and then fine sand is encountered, while on the latter the depth ranges between 12 and 16 feet, where hardpan is reached. On this latter place by careful testing two locations are said to be found for setting a gravel excavator. The stripping for both locations is from 4 to 5 feet. The material, which is about average for size and is composed of 73 per cent. limestone, 14 per cent. crystallines, 4 per cent. slate, 4 per cent. chert, 3 per cent. shale and 2 per cent. sandstone, frequently merges into a fine medium sand. Because of the unoxidized condition it will make a durable road.

By pit openings and other excavations about 2 acres are known to be underlain by gravel on the Bell place. Although no bottom has been found, the bed has been worked for 10 feet above ground-water level and 5 feet below, and the stripping is 3 feet. The sizes of the material are a little below the average.

Gravel is obtained from the bars, developed by flood deposits, in Little Blue River on the Ada Hudelton and J. Hall places, in the northeast quarter of section 16 (15 N., 10 E.).

In the flood plain of Shankitunk Creek, on the land belonging to W. S. Hall, in the northwest quarter of section 23, are about 2 acres that have been tested and are known to be underlain with gravel and fine sand. In one place the bed was tested to a depth of 7 feet below water level and no bottom found. The stripping varies between 2 and 4 feet. At other places in the flood plains of

this stream gravel is said to be present, and at several points creek gravel is obtained.

More or less gravel, mingled with fine sand, is found all along in the bluffs of Big Flatrock River from Raleigh on south. Pits have been opened in the bluffs on the farms of J. Eskew, in the southwest corner of section 36; O. Gordon, in the northwest corner of section 25; Ida Brooks, in the southwest quarter of section 24; E. Aiken, in the west central part of section 24, and George Legg, near the central part of section 13 (15 N., 10 E.).

The Eskew deposit has an extent, as known, of 15 by 150 yards, a depth to ground-water level of 10 feet and a stripping of 3½ feet. The size of the material, rock composition and oxidation are about average. Nine per cent. of clay causes this material to pack readily. The deposit on the place of Ida Brooks is probably workable. It has a stripping of 3½ feet and a material a little below the average for size.

The gravel bed on the Aiken farm is about the average for rock composition and size of material. It rests on a clay bottom, has a stripping of 3½ feet and a depth of from 4 to 12 feet. The extent is 10 by 200 yards. This material makes a smooth and durable road. Another deposit of gravel with some fine sand is found on this same farm in the flood plain, and is said to appear, by ditching and post hole boring, to underlie a surface of 20 by 500 yards. Further dimensions are not determined.

Fifteen acres have been tested with a post auger on the Legg place and are claimed to be underlain by gravel. At the pit the bed has been worked to a depth of 10 feet, where the water level was reached. The stripping is 2½ feet. The rock composition is about average and the size of the material is a little above. This material is used for several miles to the east, north and west in building and repairing roads, which, where properly looked after, are hard, smooth and durable.

In the northwest corner of section 24 and the southwest corner of section 13 (15 N., 10 E.), in the channel and flood plain of Big Flatrock River, is a bed of gravel, resting upon a clay bottom, which has a thickness where dipped that ranges between 10 and 16 feet. The surface underlain is apparently, as learned through scattered tests, 20 by 500 yards. The size of the material and rock composition are about average.

In the flood plain of the Middle Fork of Big Flatrock River locations for dipping have been found on the places of F. Lightfoot, in the southeast corner of section 19, and J. Maple, in the northeast quarter of section 8 (15 N., 11 E.). The depth on the first place is 9 feet and the stripping 4 feet; and on the second, 17 feet and stripping 3 feet. The bottom of a county ditch extending through the eastern halves of sections 26 and 35 (15 N., 10 E.) is reported to have its bottom in gravel which is below the groundwater level. No tests for dipping have been made in this vicinity.

Township 14 North, Ranges 9, 10, and Parts of 8 and 11 East.

The largest deposits of this township are found in the flood plains, terraces and bluffs of Little Blue and Big Flatrock rivers, and in a glacial ridge in the central part of the civil township of Union. Workable deposits also occur along Mud and Meadow creeks.

The continuation of the ditch, above mentioned, which passes through the eastern halves of sections 26 and 35, occurs in the eastern half of section 2 (14 N., 10 E.), with its bottom still in the gravel.

On the L. Billings and Osten places, in the northwest corner of section 24 and the southwest corner of section 13 (14 N., 10 E.), is a glacial kame which contains an unstratified bed of gravel, fine sand and clay with a thickness of 25 feet. The stripping ranges between 1 and 9 feet and the extent, although not tested, is undoubtedly workable. The sizes of the material, excepting masses of fine sand and hardpan, are 14 per cent. clay, 15 per cent. fine medium sand, 11 per cent. medium sand, 21 per cent. coarse sand, 20 per cent. roofing pebble, 15 per cent. gravel and 4 per cent. boulder; and the rock percentages are 68 limestone, 14 crystallines, 12 shale, 2 slate, 2 chert and 2 sandstone. This material is used in building and repairing the roads east to the Fayette County line. Although these roads are somewhat muddy in the winter on account of the high per cent. of clay, they become packed very quickly and are durable.

In a morainic ridge, which runs a little northeast and southwest from the south central part of section 14 to the central part of the northwest quarter of section 26 (14 N., 10 E.), several hun-

dred thousand cubic yards of a good quality of gravel are probably available. Openings in this ridge are found on the R. Hinchman place, in the south central part of section 14; S. Clifton, in the north central part of section 23, and the M. Blacklidge, in the central part of the southwest quarter of section 23 (14 N., 10 E.). The deposit at all of these openings is largely unstratified, is from 10 to 25 feet deep and contains from 1 to 4 feet of stripping. The bottom of the gravel has not been found. The general rock percentages are 68 limestone, 14 crystallines, 12 shale, 2 slate, 2 chert and 2 sandstone; and, outside of containing about 14 per cent. of clay, the sizes of the material are about average. Frequent gradations of the gravel into fine sand and hardpan are very noticeable.

This ridge for ½ mile south from the Hinchman pit is known, by post auger holes and other excavations, to be underlain with gravel, fine sand and hardpan; and for over 2 or 3 acres on the S. C. Blacklidge place, which lies just north of the M. Blacklidge farm, the gravel comes more or less to the surface. Over 1,500 loads from this ridge are used annually in building and repairing roads which, when properly cared for, are smooth, durable and giving good satisfaction.

In the bluff of Big Flatrock River, on the farms of M. Lewark, in the northwest quarter of section 28, and L. Rutherford, in the southwest quarter of section 28 (14 N., 10 E.), are some workable beds of gravel. The first has a thickness of 10 feet above ground-water level, a stripping of 2 feet and an extent of about 4 acres, and the second a thickness of 6 feet above ground-water level, a stripping of 6 feet and an extent of about 3 acres. In both deposits the sizes of the material are 6 per cent. clay, 25 per cent. fine medium sand, 25 per cent. medium sand, 19 per cent. coarse sand, 15 per cent. roofing pebble, 9 per cent. gravel and 1 per cent. boulder.

Several thousand cubic yards of gravel are deposited by the floods annually on the land belonging to T. Coleman, in the northeast quarter of section 28. The quality of this material is very good, the size being above the average and the amount of weathering below.

In the flood plains of Shankitunk Creek, in the north central part of section 3 (14 N., 10 E.), on the J. Gordon farm, are a

number of acres reported to be underlain by gravel. No tests to learn the depth have been made.

Resting upon a clay bottom, with a depth ranging between 8 and 10 feet and a stripping between 2½ and 4 feet, is a bed of gravel below ground-water level in the flood plain of Mud Creek on the J. Stephens property, in the southeast quarter of section 13 (14 N., 9 E.). Two locations have been found for setting an endless chain apparatus, and an area of 100 by 200 yards have been somewhat tested and seem to be underlain by gravel.

Along either side of a small valley on the land of H. Leisure, in the southwest quarter of section 3 and the southeast quarter of section 4 (14 N., 9 E.), are about 2 acres underlain by beds of gravel which at the pits show depths of 7 feet and strippings of 2½ feet. The size of the material is below the average and the amount of oxidation above. A morainic deposit is found in the northeast quarter of section 33 (14 N., 9 E.), on the place of D. S. Sharp. Here the stripping is 2½ feet and depth from 4 to 5 feet to water level. The extent is not known. A location for setting a gravel excavator is known on the L. McDaniels farm, in the southeast quarter of section 33. The stripping is from 3 to 4 feet and the depth from 10 to 15 feet. The size of the material is a little below the average.

A deposit of ½ fine sand and ½ average size gravel is found underlying about 3 acres, as learned by scattered tests, along Mud Creek on the farm of E. Morris, in the southwest quarter of section 22 (14 N., 9 E.). The depth where tested was 3 feet above water level and 8 feet below, and the stripping was 3 feet. The material is a little below the average for size. Another deposit along this creek, which may underlie 2 or 3 acres, is found on the T. McCoy place, in the northeast quarter of section 21. The depth is 3 feet above water level and 5 feet below, and the stripping is 3 feet. By screening out the fine sand the size of the material is above the average. Tests may prove this to be a suitable location for chaining.

A number of deposits are reported in the bluffs of Little Blue River. Among these are the J. Masy, in the southwest quarter of section 35; the A. A. Noble, in the northeast quarter of section 25 (14 N., 8 E.); the M. Churchill, in the southwest quarter of

section 19, and the G. Clendenning, in the northwest quarter of section 17 (14 N., 9 E.). The Masy bed rests upon a clay bottom, has a thickness of 9 feet and an extent of 50 by 100 yards. Both the rock composition and the size of the material are about average.

The Noble deposit is known to follow the bluff for 200 yards, to have a depth ranging from 10 to 25 feet and a size considerably below the average, but containing about 7 per cent. of a calcareous clay or fine conglomerate, which cements the material together very quickly after it is put on the road, and causes it to wear equally as well, if not better, than coarse material, with less cementing qualities. About 1,500 cubic yards of this material at 25 cents each are used in the annual repair and building of the roads for 3½ miles north and 4 miles west. These roads are smooth and durable. On this same farm, in the flood plain, 8 or 9 acres are known to be underlain by a good quality of gravel beneath ground-water level.

For 120 yards along the bluff, with a depth of 15 feet and a stripping of 4 feet, occurs the Churchill deposit. This material is about the average for size and has a rock composition of 75 per cent. limestone, 13 per cent. crystallines, 6 per cent. shale, 2 per cent. slate, 2 per cent. chert and 2 per cent. sandstone. At a cost of 35 cents per cubic yard this material is being used for road building and repairing for 3½ miles east and 4 miles west.

Resting upon a clay bottom, with a stripping of 3 feet and a depth ranging between 6 and 18 feet, is the Clendenning deposit, with an apparent extent, including flood plain, of 100 by 200 yards, which was learned through driving pipe, the uprooting of trees and groundhog diggings. The mean of two samples gives about the average size of material and rock composition for the county.

A bed of gravel beneath ground-water level lies in the flood plain of a small creek in the northeast quarter of section 15 (14 N., 8 E.), on the N. Brown property. The thickness of this bed is 18+ feet, the stripping 14 inches and the extent, which has been tested in detail, 15 by 80 yards. A considerably greater extent is undoubtedly present.

With a depth of 5 feet, a stripping of 2 feet and underlying 1 acre is a morainic deposit on the property belonging to J. Johnson,

in the northeast quarter of section 3 (14 N., 8 E.). The size of the material is considerably below the average and much oxidized.

Township 13 North, Ranges 9, 10 and Parts of 8 and 11 East.

Some large deposits are found in this congressional township in some morainic ridges in the east central part of the civil township of Walker and in the flood plains and terraces of Big Flatrock River. No other deposits of much importance are known.

In the terrace of Little Blue River in the southeast quarter of section 24 (13 N., 8 E.), on the farms of Minerva Tombes and J. Morrison, are beds of gravel which rest upon clay bottoms and have strippings ranging between 1 and 3 feet. The rock composition is about average and the size of the material considerably below. The Tombes deposit has a depth of 6 feet and an unknown extent, and the Morrison a depth of 9 feet and underlies a surface of 40 by 100 yards. The fineness and high amount of weathering of these materials place them below the average of the county for wear, but since no other known deposits are in the vicinity they are the most practicable for the local use.

In a low bluff of this same stream in the northeast quarter of section 34 (13 N., 8 E.), on the land belonging to A. Ebbing, is a bed of gravel, resting upon a clay bottom, with a thickness of from 4 to 8 feet and a stripping varying between 1 and 4 feet. Several acres tested by post auger holes are said to be underlain. The size of the material is a little below the average.

By detailed testing several locations have been found for setting a gravel excavator on the property of W. R. Fletcher, in the northeast quarter of section 7 (13 N., 9 E.). The deposit rests upon a clay bottom, has a stripping of 3 feet and a depth of 19 feet. The sizes of the material are 9 per cent. clay, 28 per cent. fine medium sand, 20 per cent. medium sand, 15 per cent. coarse sand, 15 per cent. roofing pebble, 12 per cent. gravel and 1 per cent. boulder. The amount of clay and the unoxidized condition make it a quick packing and durable road metal.

In a glacial ridge extending from the east central part of the northwest quarter of section 16 to the west central part of the southeast quarter of section 17 (13 N., 9 E.) are a number of workable deposits containing a very good quality of road-building

Plate X.

(a) The elevation on which the house and woods are located is a glacial kame, on the farm of G. Coulter, two miles west of Raleigh, in Rush County. (See page 423)

(b) Unstratified drift found in the walls of a pit on the G. Reeves farm.

material. The average width of this ridge is 150 yards. Near its northeastern part, in the southeast quarter of the northwest quarter of section 16, on the farm of G. Reeves, is a pit opening which shows an unstratified bed of gravel containing large, irregular masses of fine sand, with a depth of from 5 to 25 feet and a stripping ranging between 2 and 8 feet. This deposit, with a cross section of 100 yards across, by rough tests seems to follow the ridge southwest for 200 yards. The sizes of the material are, excepting fine sand, 8 per cent. clay, 7 per cent. fine medium sand, 2 per cent. medium sand, 9 per cent. coarse sand, 25 per cent. roofing pebble, 40 per cent. gravel and 9 per cent. boulder, and the rock percentages are 72 limestone, 14 crystallines, 7 shale, 4 chert, 2 slâte and 1 sandstone.

Advancing along the ridge for 300 yards southwest from the Reeves pit we come to the pit belonging to J. Hilligoss. Here the depth, without finding a bottom, is from 5 to 20 feet, and the material is considerably more sandy than the Reeves. Advancing still southwest from the Hilligoss pit we find fine sand almost entirely underlying the surface for about a half mile; then we come to the pits of J. English and M. Ellison, which are about 150 yards apart and contain about the same quality of gravel. This deposit is similar to the Reeves in being unstratified, having a known depth ranging between 5 and 25 feet and a stripping between 2 and 8 feet. It also has about the same rock composition. The surface underlain at this place is known to be 100 by 200 yards and is presumed to be more.

A similar deposit in size of material and rock composition is found in a kame on the G. Goddard land, in the northeast quarter of section 17 (13 N., 9 E.). The stripping is from 2 to 4 feet, the depth from 6 to 25 feet and no bottom reached, and the extent of the surface underlain is about 4 acres.

Through this township the flood plains and terraces of Big Flatrock River are said to be almost a continuous bed of gravel and fine sand. Some of the pit openings that have been made on the higher terrace are found on the farms of F. Abbercamby, in the northeast quarter of section 12; J. Durrell, in the southwest quarter of section 13, and B. Anderson, in the east central part of section 13 (13 N., 9 E.). On the I. Webb place there is a deposit in the first terrace above the flood plain.

On the Abbercamby property 9 or 10 acres are known to be underlain with about $\frac{2}{3}$ fine sand to fine medium sand and $\frac{1}{3}$ gravel. The thickness of the bed above ground-water level is 12 feet, and below it has been tested in places to a depth of 10 feet and no bottom found. The stripping ranges between 1 and 4 feet. The size of the material, excepting sand, is about average. Since the gravel is well segregated in certain portions of the pit, a number of good locations can undoubtedly be found for setting a gravel excavator.

On the J. Durrell land the pit exposure is very limited, but shows a material of average rock composition and a little below in size of material. By testing at a few points an area of 100 by 200 yards seems to be underlain by gravel and fine sand. The stripping is 4 feet and the depth unknown.

The Webb deposit, lying on the east side of the river, appears by scattered tests and a pit wall of 100 yards in length to underlie at least 5 acres of surface. The bed rests on a clay bottom, has a thickness of 7 feet and a stripping of 2½ feet. The rock composition is about the average and the size of the material a little above.

Across the river from the Webb deposit, on a low terrace, is a dug well which shows 5 feet of stripping and 7 feet of gravel without reaching the bottom. About 350 yards north of this well on the same terrace is a ditch running east and west which showed gravel at a depth of 4 feet from the surface for 150 yards. A number of loads of gravel are obtained annually from the bars developed by the flood deposits on the place of B. Anderson, in the east central part of section 13, and on that of J. Churchill, in the south central part of section 13 (13 N., 9 E.).

With exception of the gravel bed on the farm of J. Frazee, in the southeast quarter of section 14 and the northeast quarter of section 23 (13 N., 10 E.), no workable deposit is known east of the Big Flatrock River. This bed of gravel has been worked to the ground-water level without finding any bottom over 2 acres of surface, and the extent beyond this area is probably at least 2 or 3 more acres. The depth to ground-water level is 8 feet and the stripping is from 1 to 3 feet. The rock percentages are about the average, and the sizes of the material are 15 per cent. clay, 20 per

cent. fine medium sand, 22 per cent. medium sand, 15 per cent. coarse sand, 25 per cent. roofing pebble, 2 per cent. gravel and 1 per cent. boulder. Although the color is gray, the amount of weathering seems to be high, the material crumbling rather easily and not being as hard as the average. Roads for 3 miles north, 3½ miles east, 4 miles south and 3 miles west repaired and built with this material soon become rutty and are not durable.

On the W. Carney place, in the northeast quarter of section 11 (13 N., 10 E.), are about 2 acres in a glacial hill underlain by an unstratified deposit of ¾ fine sand and clay and ¼ gravel, with a depth of 15 feet and a material below the average for size. A similar deposit is said to be found on another farm belonging to the same party, in the northwest quarter of this same section.

In a flood plain on the land of D. Conner, in the northwest quarter of section 13, is a bed of gravel, with more or less fine sand and clay and below ground-water level, underlying, as learned by post auger borings and other openings, an area of 35 by 200 yards. The stripping is on the average about 7 feet.

In a deposit with a predominant amount of fine sand and clay is some gravel in a hill on the farm of J. Lindall, in the southeast quarter of section 5 (13 N., 11 E.). As a result of this insufficient supply of gravel in Noble Township only 80 per cent. of the roads have been improved, and a large part of these are very much in need of repair.

Township 12 North, Ranges 9, 10, and Parts of 8 and 11 East.

This area of 90 square miles is found in the southern part of the county and consists of the larger parts of the civil townships of Richland, Anderson and Orange. Its main gravel deposits are found in the terraces and flood plains of Big Flatrock River. Some smaller deposits are located along Little Flatrock Creek and a small stream 2½ miles west of Big Flatrock River.

In the east central part of section 25 (12 N., 11 E.) some gravel is scraped out of the bottom of Clifty Creek, but the depth is not sufficient for setting a machine for lifting it out. This is the only gravel of any practicable importance known of in the civil township of Richland.

In the bluff of Little Flatrock Creek near the east central part of section 23, on the S. Overlease place, and near the west central part of section 24 (12 N., 9 E.), on the Joseph Spurgeon land, is a bed of gravel, resting upon a clay bottom, with a thickness at the pits of 8 feet. In a square of 200 by 200 yards the following evidences of extent have been noted: In the south central part are the gravel pits, in the southwest corner is a cemetery with the graves in the gravel, and in both the northwest and the northeast corners cellar bottoms are in the gravel. At all of these exposures gradations into fine sand and clay are noticeable. Excepting the fine sand and clay, the sizes of the material are 13 per cent. clay, 22 per cent. fine medium sand, 20 per cent. medium sand, 10 per cent. coarse sand, 5 per cent. roofing pebble, 20 per cent. gravel and 10 per cent. boulder; and the rock percentages are 68 limestone, 12 crystallines, 12 shale, 3 slate, 3 chert and 2 sandstone. The material, at a cost of 25 cents per cubic yard, is used in building the roads for 4 miles north, 4 miles east, 3 miles south and 1 mile west.

On the property belonging to H. Whiteman, in the northwest quarter of section 15 (12 N., 9 E.), is probably 2,000 square yards in a bluff of a stream underlain by a bed of gravel, fine sand and clay which has a depth of 8 feet. The sizes of the material are not very satisfactory, being mainly clay, fine sand and boulders.

These two deposits complete the known gravel beds of the civil township of Anderson. The trustee of this township makes the following statement: "The township contains 65 miles of road, 8 of which have not been improved. There are no good gravel deposits in the township except that which is taken from the bars of Flatrock River. The hard, blue Laurel limestone which outcrops in the Little Flatrock Creek will probably be crushed by a small portable crusher and serve as the future road metal." The writer agrees with the trustee, in that the crushed limestone, because of its greater durability, will be the cheaper and more satisfactory road metal for the southwestern two-thirds of the township.

The bluff gravel of Big Flatrock River is exposed in a pit on the A. Willey farm, in the northwest quarter of section 4 (12 N., 9 E.). The extent is small, the depth 10 feet and stripping 7

feet. The sizes of the material are below the average. Another bluff deposit is found near the east central part of section 19, on the land of Mrs. M. Brown. The stripping is from 1 to 5 feet, the depth from 4 to 13 feet and the extent seemingly workable. The rock composition is about average and the size of the material a little above. Sixteen feet of gravel was found in digging a well back 100 yards from the bluff of Big Flatrock River on the farm of Mrs. Emma Malcomb, in the northeast quarter of section 30.

Four or five acres along a valley side are apparently underlain by gravel in the northwest corner of section 25 (12 N., 8 E.), on the place of F. Anderson. The thickness of the bed is from 4 to 8 feet and the stripping from 1 to 3 feet. The rock composition is about average and the size of the material considerably below. Gradations into fine sand are frequent.

Near the central part of section 26 (12 N., 8 E.), on the J. Hurst farm, is a deposit about like the Anderson for depth, stripping, rock composition and size of material. The area underlain, as has been learned by a few scattered tests, is about 2 acres.

In the first terrace above the flood plain of Mill Creek in the northeast quarter of section 23 (12 N., 8 W.) is a bed of gravel, resting upon a clay bottom, with a thickness ranging between 4 and 9 feet and a stripping between ½ and 2 feet. The surface underlain, as rough tests indicate, is about 3 acres; but before any openings should be made very careful tests would be essential because of the grading into fine sand. The rock composition of this deposit is about average and the size of the material a little below.

Since in the civil township of Orange a large amount of the gravel is obtained from the stream bars, in which the gravel is to a considerable extent unoxidized and almost free from clay, the roads in general do not become very muddy in the winter or very dusty in the summer; but they are slow to become packed and the material is continually working off at the sides. The durability, because of the little oxidation, is good.

LIMESTONE.

The limestone formations are found more or less in the bed and bluffs of Big Flatrock River from a mile north of Moscow south to the county line, in the bed of Little Flatrock Creek at Milroy and

other places, in the bed of Bull Fork in sections 20 and 21 (12 N., 11 E.), and in the beds of several other small streams in the southeast part of the civil township of Richland.

A small portable crusher on the Frank Moore place is said to be crushing from 60 to 100 cubic yards daily. The quarry from which this stone is obtained shows the following section:

Section at the Moore Quarry.

	Feet.	Inches.
1. Ferruginous, thin bedded limestone	6	..
2. Chert	..	3
3. Hard, gray limestone in thick beds	..	..

No. 3 is of a far better quality than No. 1, but has merely been reached and has not been worked much. No. 1 is too much weathered and is too soft to make a good wearing material, but at the same time it is found to wear far better than the gravel. In the civil township of Richland there has been built with this ferruginous material 6 miles of road which at present are smooth, hard and giving good satisfaction.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of Niagara Limestone from the Frank Moore Quarry.**

Specific gravity	2.6	French coefficient of wear	3.1
Weight per cu. ft. (lbs.)	162.2	Hardness	4
Water absorbed per cu. ft. (lbs.)	2.32	Toughness	5
Per cent. of wear	12.7	Cementing value—Dry	13
		Wet	24

"A very soft dolomite with a fair cementing value."—Page.

A chemical analysis by the chemist at the Road Testing Laboratory shows the composition of the limestone to be as follows:

Chemical Analysis of Niagara Limestone from the Frank Moore Quarry.

	Per cent.
Alumina (Al_2O_3)	.50
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	31.05
Magnesia (MgO)	20.53
Sulphuric acid (SO_3)	Trace
Insoluble in hydrochloric acid	3.04
Loss on ignition	44.32
Total	99.69

*For standard of comparison see p. 79.

This portion of the county has no gravel and no railroad facilities. Because of these facts the most economical way in which to obtain a road metal is to set the small portable crusher at the most convenient and least weathered outcrops in the vicinity in which the material is needed and crush the required amount.

For the regions which have neither limestone or gravel in the civil townships of Orange, Walker, Posey and Jackson the transportation facilities are excellent, and crushed limestone can be shipped within a few miles of where it will be used.

HENRY COUNTY.

Area in square miles	395
Population in 1900	25,088
Miles of public road	500
Miles of improved road	435
Percentage of roads improved	87
Miles improved with gravel	435
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,800
Total original cost of improved roads	$783,000
Annual cost of repairs per mile on gravel roads 5 years old	$75
Miles of improved road (gravel) built in 1905	6
First improved roads built	1850
Proportion of improved roads built since 1895 (per cent.)	10
Satisfaction of farmers with investment in improved roads	Good
Authority	John M. Bundy, County Auditor

Henry County is situated in the east central part of the State and is bounded on the north by Delaware, on the west by Hancock and Madison, on the south by Fayette and Rush, and on the east by Wayne and Randolph counties. It is separated from the boundary line of the State of Ohio by the two counties last named. The county is from 19 to 20 miles wide from east to west and 20 miles in length from north to south.

A moraine which forms the divide between East and West White rivers crosses this county from the northeast to the southwest, passing the central part northwest of New Castle. It is rather pronounced in the northeastern portion, containing numerous kames and shallow kettle basins, but becomes more subdued in the southwest. Along the eastern border is a moraine which constitutes the divide between the East White and the Whitewater River systems. Another moraine follows Flatrock Creek south

from the central part of the county. Between these morainic ridges are slightly undulating plains somewhat lower in elevation.

The surface rocks of the county are almost everywhere hidden by a heavy mantel of drift, which at New Castle reaches a thickness of 500 feet. At the quarry mills three miles southwest of

HENRY COUNTY.

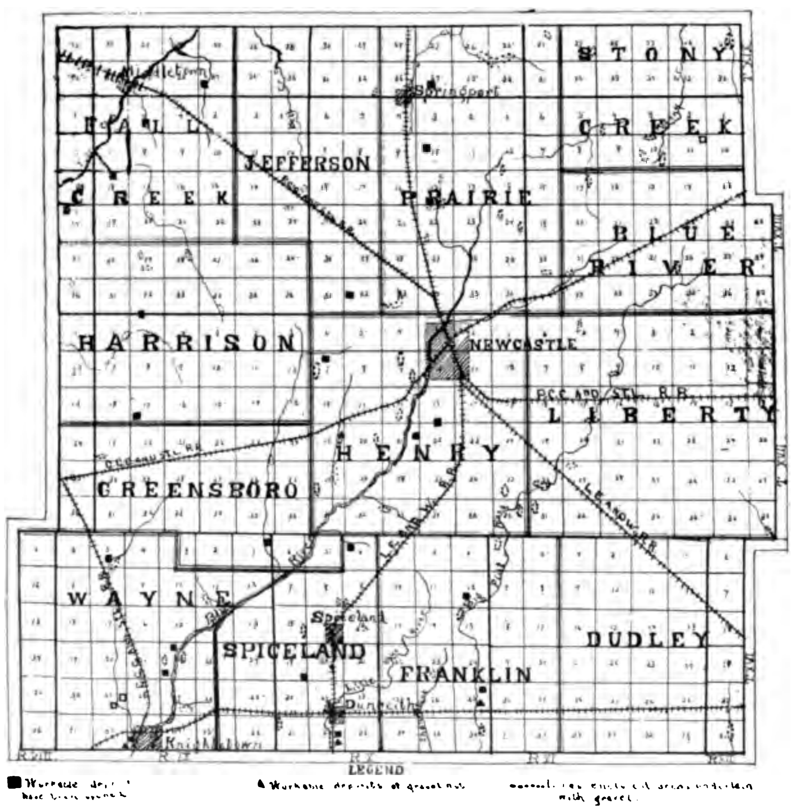

Fig. 34. Illustrating the distribution of road materials in Henry County.

Greensborough the only outcrop of Niagara limestone known in the county is found.

In both amount and quality the gravel of this county is about the average for central Indiana. The principal deposits are confined to the bluffs, terraces and flood plains of the larger streams and to the morainic ridges. The average sizes of the material are 11 per cent. clay, 16 per cent. fine medium sand, 16 per cent.

medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 16 per cent. gravel and 1 per cent. boulder; and the average rock composition is 88 per cent. limestone, 8 per cent. crystallines, 1 per cent. chert, 1 per cent. slate and 2 per cent. shale. Some sandstone and argillite are also present.

The transportation facilities are very good. Intersecting at New Castle and extending in all directions are the Peoria & Eastern division of the Big Four, the P., C., C. & St. L. and the Ft. Wayne, Cincinnati and Louisville. Besides these is the Connersville branch of the Ft. Wayne, Cincinnati and Louisville running southeast and the R., D. & I. interurban, running southwest from New Castle. In addition the Indianapolis division of the P., C., C. & St. L. crosses from east to west near the southern border of the county and the Michigan division of the Big Four cuts the southwestern corner.

Township 18 and Part of 19 North, Ranges 9, 10, 11 and Part of 8 East.

This area of 156 square miles, comprising the northern portion of the county, embraces the civil townships of Stony Creek, Blue River, Prairie, Jefferson, Fall Creek and the northern part of Harrison. Its main gravel beds are found in the morainic ridges, the terraces and flood plains of Fall Creek, Flatrock Creek, Stony Creek, Blue River and its larger tributaries.

On the valley side of a small stream, on the property of Mrs. S. Keesling, in the north central part of section 24 (18 N., 8 E.), is a 10-foot bed of gravel, beneath from 1 to 4 feet of stripping, underlying an area of 6 acres, as has been learned by pit openings and dug wells. The gravel is from a brown to a yellow in color, and is about the average for size, rock composition and quality.

About 1,000 wagon loads are sold annually, at 10 cents per cubic yard, and are used for 4 miles south, 2 miles east, ½ mile north and 2 miles west in building and repairing the roads.

Another workable deposit is located in the central part of section 13 (18 N., 8 E.), in a bluff to a tributary of Fall Creek, on the Amos Keesling farm. It has a thickness of 22 feet, an extent of 10,000 square yards and is covered with 2 feet of surface. The quality, output and use are similar to those of the preceding de-

posit. Both of these deposits grade into hardpan and fine sand. Probably $\frac{2}{3}$ of the latter is fine sand.

Beneath the ground-water level on the place of Samuel Weishart, in the northwest quarter of section 36 (18 N., 8 E.), is a bed of gravel which has been tested by the trustee of Harrison township to a depth of 18 feet. A good quality of gravel is reported.

Also in the central part of section 29 (18 N., 9 E.) is a possible location for dipping or *chaining, gravel of a fine quality having been taken out to a depth of 6 feet, where water was encountered, over several thousand square yards. This location would be an especially favorable one because material is being hauled for 3 miles for the roads in this immediate vicinity.

The trustee of Harrison Township found 11 feet of a good material in driving a 1½-inch pipe at the south central part of section 34 (18 N., 9 E.). The extent was not determined.

Beneath 5 feet of surface in a flood plain near the central part of section 20 (18 N., 9 E.) 40 feet of gravel and sand have been found by means of a churn drill. Further testing will be necessary before anything definite can be known as to the area covered.

Along the valley side of a tributary to Fall Creek, on the farm of Isaac Myers, in the northeast quarter of section 18 (18 N., 9 E.), is a bed of gravel under from 1 to 9 feet of surface, with a thickness of 22 feet and an extent of 2 acres, as indicated by crude tests. The quality as to size and rock percentages are about the average. About 1,000 loads of this material are put on the roads annually for 2 miles north, 4 miles east, 5 miles south and 1 mile west.

In the southeast quarter of section 6 (18 N., 9 E.), on the W. W. Terres place, is a bed of gravel on the valley side of a tributary to Fall Creek that under 2 feet of surface has a thickness of 10 feet and underlies about 1 acre. The size is slightly below the average and the rock composition about the same. It is used, at a rate of 15 cents per cubic yard, for 1 mile north, 3 miles east, 2 miles south and 1 mile west.

Another deposit similar to the Terres in size, rock percentages, depth, stripping, output and use is found underlying about 2 acres in the south central part of section 5 (18 N., 9 E.), on the N.

*See page 324.

Riley property. This gravel grades frequently into hardpan and fine sand.

Fair bank deposits are found in the bluffs and terraces of Fall Creek in sections 28 and 29 (19 N., 9 E.), and 7 (18 N., 9 E.), and others will undoubtedly be found when the demand requires them.

A bed of gravel in a stream bluff is found on the Thomas Pierce farm, in the southwest quarter of section 34 (19 N., 9 E.). The thickness is from 10 to 12 feet, without any bottom being found. The extent, as has been learned by some rough tests, seems to be 2 or 3 acres, and the stripping is from 3 to 5 feet. This material is somewhat above the average for quality and contains a calcareous clay which aids it in packing and wearing. The sizes are 12 per cent. clay, 15 per cent. fine medium sand, 15 per cent. medium sand, 15 per cent. coarse sand, 25 per cent. roofing pebble, 19 per cent. gravel and 1 per cent. boulder. At a cost of 20 cents per cubic yard it is used on the roads for ½ mile north, 4 miles east and 4 miles south.

In the civil township of Jefferson there is only one gravel pit, and this is found on the property of L. Lewis, in the northwest quarter of section 32 (18 N., 10 E.), in a kame deposit. From various tests it seems to underlie an area of 1½ acres, has a stripping ranging between 2 and 4 feet and is from 10 to 15 feet deep. The size at the pit is a little above the average, being 12 per cent. clay, 16 per cent. fine medium sand, 22 per cent. medium sand, 10 per cent. coarse sand, 20 per cent. roofing pebble, 19 per cent. gravel and 1 per cent. boulder. The rock percentages are about the average. Some 300 cubic yards are used, at 15 cents per cubic yard, in the annual repairing of the roads for 2 miles north, 2 miles east, 5 miles west and 2 miles south.

In this same civil township in the southwest quarter of section 32 (19 N., 10 E.), the northeast quarter of section 36 (19 N., 9 E.), the southeast quarter of section 13 (18 N., 9 E.) and the north central part of section 24 (18 N., 9 E.) are gravel deposits below the ground-water level. The extent or depth of none of these has been determined. The first was found in digging a tile ditch which was 4 feet in gravel. To this location the nearest gravel deposits that are being worked are 5 or 6 miles, two loads being a day's work for a team. In the third location, which is on

the Daniel Jones place, the gravel is found by digging with a post auger in a stream bed. The fourth, on the John Sherly farm, is known by a very shallow bank pit, in which no bottom other than water was found.

Because of the scarcity of gravel and the high expense in obtaining it in Jefferson Township the writer would suggest for those vicinities near the railroad that a crushed limestone be shipped to the most convenient switches. Its durability would probably make it in the long run the cheaper road material.

A workable deposit is found on the land of W. T. Shively, in the southwestern part of section 22 (18 N., 10 W.). The bed is 9 feet thick and is covered with from 1 to 2½ feet of soil. The gravel is a little below the average in size, amount of clay and oxidation. The color is brown and the rock composition about the average.

In the south, central and western parts of section 33 (18 N., 10 E.), in an old flood plain, is a ditch 2½ feet in gravel for about ½ mile. The size of this material is a little below the average, but it is unoxidized. Great abundance could very likely be dipped at this location.

About 6 or 7 beds of gravel are found along the valley sides just east of Mount Summit, in the northwestern part of section 22 and the south central of 15 (18 N., 10 E.). A typical section taken from the W. White land is as follows:

Section from a Pit on the W. White Farm.

	Feet.	Inches.
1. Stripping	1	..
2. A brown gravel of average size, considerably weathered	1	6
3. A brown medium sand	1	..
4. A light brown gravel, a little above the average in size	2	..
5. A brown medium sand	..	6
6. A light brown gravel of average size, and little oxidized	1	..

Probably 40,000 cubic yards of this material could be obtained in this vicinity by doing some screening.

In quality the gravel on the J. Rutledge place, in the northeast quarter of this same section, is similar to the White. The amount is probably 2,000 cubic yards.

In the west central part of section 10 (18 N., 10 E.), on the farms of C. W. Sivard and J. T. Hickman, are some deposits lo-

cated in ridges. Probably 15,000 square yards are underlain by a bed of gravel from 4 to 18 feet in thickness. The stripping is from 1 to 4 feet. The size is above the average, there being 7 per cent. clay, 8 per cent. fine medium sand, 5 per cent. medium sand, 10 per cent. coarse sand, 50 per cent. roofing pebble, 19 per cent. gravel and 1 per cent. boulder. The oxidation is below the average, and the rock percentages are 88 limestone, 7 crystallines, 2 chert, 2 shale and 1 slate. This material is used for 1 mile north, 1 mile south, 4 miles west and 1 mile east.

A glacial ridge, locally known as the "backbone," with a very hummocky topography and shallow kettle basins, extends northwest and southeast through the central part of section 10 and the central and eastern parts of 3 (18 N., 10 E.), and through the western part of 34 and the eastern part of 33 (19 N., 10 E.). At a number of points it is known to contain gravel, but has been opened only on the J. Clawson place along the road, in the southwestern part of section 34 (19 N., 10 E.). This bed, by rough tests, seems to underlie 2 or 3 acres, to have a depth of 12 feet, and from 1 to 3 feet of stripping. It is above the average in size, about the same in rock percentages and less in oxidation.

A cross section presents a conglomeration of clay and fine sand lenses, gravel and boulders, no stratification being present. Fully half of the deposit is made up of the clay and fine sand lenses, which have to be worked around in obtaining the gravel. The amount of gravel that can be taken from this glacial ridge will very likely be well up in the hundreds of thousands of cubic yards.

In the northeastern corner of section 27 (19 N., 10 E.) and in the bluff of a stream, on the land of Mrs. L. Robe, is a bed of gravel which underlies about 1 acre, has a thickness of 15 feet at the pit and has 1 foot of stripping. The size is below the average and the rock composition is about the average. This material at many places grades abruptly into a fine sand.

Going west from Luray one follows for about 2½ miles a branch of a tributary of White River. In flood plains, terraces and bluffs large quantities of gravel and sand are known to be present. A general average of the gravel is found in the bluff in the northwest quarter of section 36 (19 N., 10 E.), on the farm belonging to the Patterson heirs. Two pits, either of which have

a section of 11 feet, show about the average in size and oxidation, and a rock composition of 88 per cent. limestone, 9 per cent. crystallines, 1 per cent. chert, 1 per cent. slate and 2 per cent. shale. Frequently the gravel grades into sand which has to be screened or worked around. The gravel from none of the pits in this vicinity is used on the road for farther than ¾ of a mile from where it is obtained. The roads, with the exception of along the hillsides, where the clay can not keep the gravel in place, are smooth and hard.

Gravel with similar characteristics to these is found in the bluffs and terraces of Prairie Creek in the northeast quarter of section 30 (19 N., 11 E.).

For over 400 yards along the east bluff of Blue River, on the places of M. Harvey, in the southwest quarter of section 12, and R. D. Harvey, in the northwest quarter of section 13 (18 N., 10 E.), a bed of gravel has been found to occur. A dug well 150 yards back from the bluff face shows the following record: (a) Soil, 8 feet; (b) brown sand, 30 feet; (c) a good quality of gravel with an unknown depth. The available portion of the bed has a thickness of 8 to 10 feet. In size it is below the average and is above in amount of oxidation.

One mile south, in the same bluff, another bed of like quality is found on the N. Harvey property, in the northwest quarter of section 24 (18 N., 10 E.). This bed is known to extend along the bluff for 200 yards.

One acre is probably underlain by a bed of gravel, which grades abruptly into sand in many places, on the R. B. Ridgway property, in the south central part of section 30 (18 N., 11 E.). The stripping is from 1 to 2 feet, and the depth undetermined. The quality is very durable, the sizes being 12 per cent. clay, 5 per cent. fine medium sand, 5 per cent. medium sand, 5 per cent. coarse sand, 20 per cent. roofing pebble, 45 per cent. gravel and 8 per cent. boulder. The rock percentages are 86 limestone, 10 crystallines, 2 chert, 1 slate and 1 shale.

Under from 1 to 4 feet of surface, on the land of William Graham, in the southwestern corner of section 29 (18 N., 11 E.), in a low, flat ridge which runs parallel with a stream, is a poorly stratified bed of gravel and sand which underlies an area of 100 by 30

yards. A section shows: (a) Stripping, 3 feet; (b) brown gravel, much below the average in size, 3 feet; (c) brown fine sand, 3 feet, and (d) a gray, brownish gravel, much below the average in size, at the bottom. Although this gravel is used for 4 miles north, 2 miles south and 1 mile east and makes a smooth road, it is not as durable as a coarser and less oxidized material.

In a glacial ridge on the land of Henry Current, in the southwestern corner of section 4 (18 N., 11 E.), is a bed of gravel underlying, as is seen by two pits 100 yards apart and several intervening tests, an area of at least 100 by 60 yards. An average section through the gravel shows: (a) Stripping, 1½ feet; (b) a brown gravel, slightly below the average in size, 2 feet; (c) a brown gravel, a little above the average for size, 2 feet; (d) a light brown, average size gravel, 7 feet. In places the merging of the gravel into fine sand and clay is very conspicuous. The rock percentages are 85 limestone, 11 crystallines, 1 slate, 1 chert and 2 shale, and the durability is above the average.

In a morainic ridge in the southeast quarter of section 29 (19 N., 11 E.), on the place of Jerry Current, is a heterogeneous bed of gravel, sand and clay underlying 1 or 2 acres. The stripping is from 1 to 3 feet and the depth is 18 feet to ground-water level, below which it is not known. The size is above the average, there being as high as 10 per cent. of boulders in parts of the deposit. The rock composition is similar to that of the Henry Current deposit in the preceding paragraph. This material, which is used in building and repairing roads for 2 miles south, 1 mile east, 1 mile north and 2 miles west, has proven to be a satisfactory and durable road metal.

A similar deposit in rock composition and size of material, except for a higher per cent. of clay, is found in a kame on the land of Mary Oxley, in the northeastern corner of section 3 (18 N., 11 E.). The area underlain is 150 by 30 yards, the depth is 12 feet and the stripping from 2 to 4 feet. About ⅔ of this deposit is made up of large, irregular masses of hardpan and fine sand, which have to be worked around, thus making a large part of the gravel rather unavailable.

The deposits on the farms of T. J. Dean, in the northwest quarter, and O. Conaway, in the southwest quarter of section 10 (18

N., 11 E.), are similar to the Oxley in topographic position, in quality and in heterogeneous mixture of gravel, sand and clay. Neither of these deposits are known to be workable.

Another morainic deposit is found on the Lydia Davis place, in the northeast corner of section 11 (18 N., 11 E.). It underlies, as has been learned by digging, at least 1 acre, is 14 feet deep and has from 2 to 6 feet of stripping. The size and quality are a little below the average, but are the best found in the northeast part of Blue River Township. The rock percentages are 85 limestone, 11 crystallines, 2 shale, 1 slate and 1 chert. About 570 cubic yards of the material are put on the roads annually for 3 miles north, 1 mile east, 1 mile south and 1 mile west.

Without a doubt many more good gravel deposits can be found in some of the many kames and glacial ridges of sections 2, 3, 4, 9, 10, 11 and 12 (18 N., 11 E.) when the demand requires them. Before opening such deposits careful testing should be made by driving down a 1½-inch pipe, because of the frequent grading from gravel to sand and clay.

In the flood plain of Flatrock Creek, on the land of Lawrence Hiatt, in the southwestern corner of section 26 (18 N., 11 E.), under from 2 to 5 feet of soil, is a bed of gravel and sand having a thickness ranging between 6 and 12 feet and an extent of 10 acres, as rough testing has indicated. The size and rock composition of the material is about the average for the county.

In the central part of section 34 (18 N., 11 E.), in a low, flat hill on the G. R. Koons farm, is an area of 150 by 25 yards underlain by a bed of gravel from 9 to 12 feet deep and with from 1 to 3 feet of stripping. The quality is about the average.

The average price paid for gravel in range 9 north is 12½ cents, and in 10 and 11, 10 cents. About 65 per cent. of the roads in this congressional township are either dirt or in need of extensive repairs. With the exception of the civil township of Jefferson and a few other very limited localities the area is well supplied with good gravel.

Township 17 North, Ranges 9, 10, 11 and Parts of 8 and 12 East.

This area of 117 square miles is a rectangle with a length of 19½ miles from east to west and a width of 6 miles from north to south. It embraces the civil townships of Liberty, Henry, Greens-

boro and the southern two-thirds of Harrison. The gravel deposits are for the most part found in the flood plains, terraces and bluffs of the larger streams.

In range 11 no deposits of economic importance are known east of Flatrock Creek except in the central and south central portions of section 32, where 1,000 loads are obtained annually from the flood deposits of a tributary to the West Branch of Whitewater River. This absence of gravel has been learned through logs of dug wells, which show beds of only a few feet in thickness.

The writer would suggest for this locality that the cost of getting the more durable road metal, crushed limestone, to the nearest railroad switches be considered. A general statement as to the cost of this material may be found on page 156, and the results of tests by the U. S. Road Testing Laboratory for limestones in this part of the State on pages 157-159.

Along Flatrock Creek on the Frank Milligan farms, in the east central part of section 9 and the southeast quarter of section 17; on that of Frank Worlds, in the northwestern corner of section 21; on that of the Boyd brothers, in the southwest quarter of section 30, and on that of the Peed heirs, in the northwest corner of section 31 (all in 17 N., 11 E.), are deposits of gravel with about the average size, and rock composition that grade into clay and sand. They are all used in repairing and building the roads, at 10 cents per cubic yard, for about 3 miles east. The first is found on the valley side, has from 1 to 7 feet of stripping, underlies 2 or 3 acres, as rough tests have indicated, and is 7 feet deep. The second has an extent of 15,000 square yards, as has been learned by various diggings, is beneath from 1 to 4 feet of surface and has a depth varying from 5 to 8 feet. The third is located in the flood plain and low terrace of a small tributary to Flatrock Creek, underlies, with from 1 to 4 feet of stripping, 3 or 4 acres, as was learned by post auger tests, and has a depth of from 4 to 9 feet. The fourth has not been tested. The fifth is situated in the stream bluff, is beneath from 1 to 4 feet of soil, has an extent of 2 or 3 acres and a depth ranging between 5 and 10 feet. The last is located in the valley plain of a small tributary to Flatrock Creek, is as much as 9 feet deep to water level, has 2 to 3 feet of stripping and may extend over 1 or 2 acres, but tests are lacking. Before pit openings are made in these deposits or any others along this

stream very careful *testing will be helpful, because 70 per cent. of these deposits is clay and fine sand, and the grading into these is often very sudden and frequent.

A little east of the central part of section 5 (17 N., 11 E.), on the Boyd brothers property, is a deposit of gravel beneath 6 feet of surface, with an unknown extent and a depth of 6 feet. The quality is exceptionally good for a bank deposit; the sizes, as taken from the average of three samples, are 10 per cent. clay, 15 per cent. fine medium sand, 8 per cent. medium sand, 12 per cent. coarse sand, 25 per cent. roofing pebble, 22 per cent. gravel and 3 per cent. boulder. The rock percentages are about an average for the county. The roads built and repaired by this material are hard, smooth and durable.

In the northeast quarter of section 36 (17 N., 10 E.), along a small creek on the place belonging to Walter Malot, is a bed of gravel and fine sand which underlies 2 or 3 acres. Its thickness above ground-water level is 9 feet and is unknown below. The stripping ranges between 1 and 3 feet. The rock percentages are about the average and the size is a little above.

On the property belonging to Frank Bundy, in the southwest quarter of section 25 (17 N., 10 E.), is a bed of gravel in a kame which stands out pronouncedly above the adjacent country. This bed is beneath about 2½ feet of surface, is 10 to 15 feet thick and underlies a surface of 200 by 20 yards. The mean of two samples gives about the average size for the county. The oxidation and rock composition are also about average. The material contains from 14 to 15 per cent. of clay, which makes it pack quickly when put on the road, but also makes them rather muddy in the winter. About 400 cubic yards of this material, at a cost of 10 cents per cubic yard, are used in the annual repair of the roads for 2½ miles south and 1 mile north.

Passing west from this deposit no other is found until the bluffs and terraces of Blue River and some of its tributaries are reached. Along a tributary to Blue River, on the L. Hodson farm, in the northeast quarter of section 32 (17 N., 10 E.), is a bed made up of 2-5 gravel, ¾ fine sand and 1-5 hardpan, beneath 1 to 6 feet of surface and with a thickness of 17 feet. The fine sand and gravel

*See page 320.

are segregated from one another. The mean of two sizes gives about the average for the county. The material is used in building and repairing the roads for 1½ miles north, 2 miles east and 2½ miles south. These roads are in general smooth, hard and giving good satisfaction.

On the bluff of Blue River in the south central part of section 15 (17 N., 10 E.) is a bed of gravel and sand with a thickness of 39 feet, a stripping of 3 feet and extent of 2,000 square yards. The sand and gravel often grade into one another. The sizes as taken from the average of three samples are 7 per cent. clay, 13 per cent. fine medium sand, 13 per cent. medium sand, 30 per cent. coarse sand, 17 per cent. roofing pebble, 15 per cent. gravel and 5 per cent. boulder. The rock percentages are 89 limestone, 8 crystallines, 1 chert, 1 shale and 1 slate.

In the northern part of New Castle, on lots owned by L. A. Jennings and Margaret Finley, are beds of ⅓ gravel and ⅔ sand underlying 2 or 3 acres. They have from 4 to 6 feet of stripping and are 12 feet deep. They are below the average in size, the coarsest material being little better than a coarse sand.

A small deposit of somewhat above the average for size is found on the property of M. D. Harvey, in the southeastern corner of section 9 (17 N., 10 E.), in the bluff of Blue River.

Numerous deposits that have not been opened are known by well logs and other excavations to exist in the flood plains, terraces and bluffs of Blue River.

Along a tributary to Blue River are a number of deposits in section 30 (17 N., 10 E.). Those being used are on the farms of John Huddleson, S. Rite, H. H. Harvey and E. K. Stratton. All of these are similar in having a material of about the average size and being located at the top of the stream bluffs. Although the gravel frequently grades into sand, yet tests that have been made by pits, wells, groundhog diggings and post auger borings show that it is very probable that 200,000 cubic yards are accessible in this locality.

Farther up this same stream, in the northeast quarter of section 19 (17 N., 10 E.), is a location on the farms of Emma McDorman and Maryette Roof. The former is in a ridge running parallel with the creek, which is known to have a bed underlying 5 or 6

acres, as learned by plowing and the withering of crops in dry weather, with a depth where a well was dug of 30 feet and no bottom found. The latter deposit has a depth of 10 feet and is also located in a ridge whose length is parallel with the stream. Here we find a bed 10 feet thick and workable in extent. The size of the material, taken from the average of two samples, is 12 per cent. clay, 13 per cent. fine medium sand, 18 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble and 17 per cent. gravel. The rock percentages are 84 limestone, 12 crystallines, 2 shale, 1 slate and 1 chert.

On the county farm, in the northeast quarter of section 9 (17 N., 10 E.), is a bed of gravel, sand and clay in a stream bluff, beneath from 2 to 4 feet of surface. It probably underlies 8,000 square yards, as learned from rough tests, and has a thickness of 15 feet. The size is about the average.

In the east bluffs of Duck Creek numerous tests have been made which show a deposit of gravel to continue, more or less broken by the valleys of small intermittent tributaries, from the southwestern corner to the east central part of section 7 (17 N., 10 E.). Pits have been opened on the M. McCormick, I. Mendenhall and Mrs. A. Lowery farms. They show from 1 to 3 feet of stripping and depths from 8 to 12 feet. The sizes range from the average up to a sample which contains 9 per cent. clay, 12 per cent. fine medium sand, 5 per cent. medium sand, 5 per cent. coarse sand, 30 per cent. roofing pebble, 37 per cent. gravel and 2 per cent. boulder. The rock percentages are 87 limestone, 8 crystallines, 3 chert, 1 slate and 1 shale. About 1,500 loads, at 10 cents per cubic yard, are used in the annual repairing of the roads for 4 miles north, 3 miles east, 2 miles west and 1 mile south. Almost all of these roads are in very good condition, being hard, smooth, well packed and durable.

In the southwestern corner of section 13 (17 N., 9 E.), on the place of T. C. Phelps, is a deposit of gravel, sand and clay, beneath from 1 to 3 feet of soil, that underlies 10 acres, as has been learned by dug wells, post auger holes and plowing. The depth is from 4 to 9 feet. The sizes of the material are 9 per cent. clay, 15 per cent. fine medium sand, 11 per cent. medium sand, 15 per cent. coarse sand, 40 per cent. roofing pebble and 10 per cent.

gravel. The rock percentages are 86 limestone, 10 crystallines, 1 chert, 1 slate and 2 shale. Some 2,000 cubic yards are put on the roads annually for 5 miles north, 3/4 mile south, 1 mile east and 3 miles west. The wearing quality is good.

Along the valley side and in an upper terrace of Duck Creek, on the Frank Starbuck and Milton Stafford farms, in the southeastern corner of section 23 (17 N., 9 E.), and in the northeastern corner of section 26 (17 N., 9 E.) are gravel and sand deposits underlying about 1 acre. The depth to ground-water level is 4 to 8 feet, below which it is unknown. The quality and size of the material are about an average, but the stripping being heavy, the bed thin and the hardpan considerable, the deposit is hardly a practical one. The material has been used for 2 miles north, 1 mile south, 1/2 mile east and 4 miles west, and has given good satisfaction.

West of Duck Creek in Greensboro Township there is no gravel at all with the exception of a very fine material on the farm of L. H. Judge, in the southwestern corner of section 19 (17 N., 9 E.). At this place the gravel is below ground-water level and no bottom has been found.

In an isolated kame, which was known as the "Mountain" in earlier days because of its rising some 40 feet above the surrounding country, in the southwest part of section 17 (17 N., 9 E.), on the farms of H. Wilkerson and William Hedrick, is a heterogeneous mixture of clay, gravel and sand beneath from 2 1/2 to 8 feet of surface and underlying 1 1/2 acres, with a depth ranging from 3 to 18 feet. About all sizes are found, but in all cases the clay runs high, 19 per cent. being common. This causes the roads on which the material is used to be somewhat muddy, but otherwise they are very satisfactory. These roads are found as far as 4 miles east, 3 miles south, 2 1/2 miles west and 3 miles north. No known workable deposit is known nearer than 2 miles north, 4 miles east, 4 miles south and 3 miles west.

In a morainic hill in the north central part of section 5 (17 N., 9 E.) and the south central part of section 32 (18 N., 9 E.) is a bed of gravel, clay and sand underlying about 3 acres. This has been determined by a cellar 75 yards northeast of the pit, where gravel was found beneath 6 feet of clay, and a dug well 75 yards

farther northeast, where gravel was reached after passing through 12 feet of clay. Six feet of stripping under common circumstances would make a deposit impractical; but since the nearest deposits of no better quality are several miles distant, this bed can be worked with profit. At the pit the depth is 18 feet and the stripping 6 feet. The sizes are 18 per cent. clay, 10 per cent. fine medium sand, 10 per cent. medium sand, 10 per cent. coarse sand, 20 per cent. roofing pebble, 30 per cent. gravel and 2 per cent. boulder. The rock percentages are 85 limestone, 12 crystallines, 2 shale and 1 chert. The material is used on the roads for 3 miles north, 2 miles east, 2½ miles west and 1 mile south.

Locations for dipping have been tested for depth by the trustee of Harrison Township in the east central part of section 6 (17 N., 9 E.), where 17 feet of gravel were found; and in the south central part of section 10 and the northern part of section 15 (17 N., 9 E.), where 9 feet of material were found. The extent in none of these cases has been determined.

For this congressional township 10 cents per cubic yard is the general price.

Because of the scarcity of gravel, in the central portion of the civil township, Harrison, and the central and western portion of Greensboro, the writer would suggest that the cost of getting the more durable road metal, limestone, to the nearest railroad switches, be considered.

Township 16 North, Ranges 9, 10, 11 and Parts of 8 and 13 East.

This area forms a rectangle 20 miles long from east to west, and 6 miles wide from north to south. In it are found the civil townships of Wayne, Spiceland, Franklin and Dudley. With exception of a few morainic deposits, all of the gravel of economic importance is confined to the bluffs, terraces and flood plains of Blue River with its larger tributaries, Little Blue River and Flatrock Creek.

In the south central part of section 5 (16 N., 9 E.), on the land of O. P. Manlove, is a deposit in the flood plain of a tributary to Blue River. The stripping is from 1 to 3 feet, the depth 6 feet above water level, at the pit, and the area underlain is at least ½ acre, where Mr. Manlove has tested thoroughly to a depth

of 5 feet below water level. These tests point to a favorable possibility for *chaining, which I think will be the more satisfactory method of lifting the gravel out at this location, on account of the high percentages of clay. The rock composition is about the average, the size is a little above, and the oxidation much lower. The per cent. of clay is very high, which makes the roads muddy in the winter and dusty in the summer. This material is used on the roads for 1 mile north, 2 miles south, 2 miles west and 1 mile east.

A similar deposit is found in the southeastern corner of this same section, on the M. Vandenbark land. The extent and depth are not known.

Some 30 feet above a stream, in a bluff, on the Charles Addison place, in the southeast quarter of section 29 (16 N., 9 E.), beneath 3 feet of soil, is a workable deposit of gravel, with a depth ranging between 5 and 11 feet. This deposit contains a low per cent. of fine sand and clay. The size is a little above the average, and the oxidation below. The rock percentages are 86 limestone, 10 crystallines, 2 chert, 1 slate and 1 shale. The material is put on the roads for 4 miles north, 4 miles west, 2 miles east and 1 mile south. These roads are smooth, hard and durable.

In the eastern part of Knightstown 7 or 8 acres are known, by careful tests, to be underlain by gravel, on the property belonging to the I. & E. St. Ry. Co. These tests have shown, at the present pit, which is situated just back from the edge of the bluff, a depth of 12 feet and a hardpan floor. As one gets farther from the bluff edge, the gravel bed becomes thinner and the hardpan floor comes nearer to the surface. At 100 yards the bed of gravel is 2 feet thick, and the hardpan floor is within 5 feet of the surface. The stripping varies from 1 to 3 feet. The quality of the material is a little above the average, the sizes being 8 per cent. clay, 15 per cent. fine medium sand, 17 per cent. medium sand, 13 per cent. coarse sand, 30 per cent. roofing pebble, 15 per cent. gravel and 2 per cent. boulder. The rock composition is about the average. About 250 cubic yards of the material are hauled out daily, for use as ballast, along the interurban line.

In the southwest quarter of section 22 (16 N., 9 E.), 1/4 mile

*See page 324.

from the river, in its bluffs, is a bed of gravel on the property of O. Morris. It underlies about 2,000 square yards, has a depth of 9 feet, and 2½ feet of stripping. The material in size, rock percentages and durability is about the average for the county.

In the first terrace above the flood plain of Blue River in the north central part of section 22 (16 N., 9 E.), is a bed of gravel beneath 2½ feet of surface, with a thickness of 9 feet, and an extent over a considerable area, as is seen by a ditch, which is in this terrace for a distance of 400 yards north with its bottom in the gravel. The mean size of two samples gives about the average for the county. The rock percentages are the average. The material is used on the roads for 1 mile south, 1½ mile west, 3 miles east and ¼ mile north.

In sections 11 and 15 (16 N., 9 E.), an abundance of gravel is known to exist in the bluffs of Blue River. Small pits have been opened at various points, and, in general, contain material very similar to that described in the two preceding paragraphs.

On the farms of Earl Moffitt, in the northeast quarter of section 1 (16 N., 9 E.), and that of B. Reese, in the west central part of section 6 (16 N., 10 E.), are a few of a number of workable deposits in the bluffs of Duck Creek. These beds occur beneath from 1 to 3 feet of surface, and are 25 feet deep. The sizes of the material are 6 per cent. clay, 17 per cent. fine medium sand, 13 per cent. medium sand, 14 per cent. coarse sand, 30 per cent. roofing pebble, 18 per cent. gravel and 2 per cent. boulder; the rock percentages are 86 limestone, 9 crystallines, 2 shale, 2 chert and 1 slate; and the oxidation is about the average. This material makes smooth and durable roads.

A deposit of gravel and sand is found on the property of Samuel Hoover, in the northwest quarter of section 4 (16 N., 10 E.), along a small tributary to Blue River. It has a depth of 9 feet to water level, and an unknown depth below, a stripping of from 2 to 6 feet, and an extent of 2 acres. The mean of two samples gives about the average size for the county. A deposit containing material very similar to this of the Hoover place is found on the property of Theodore Applegate, 1 mile due east of Spiceland. The amount of gravel is not known.

A workable deposit, from which 2,000 cubic yards of gravel are

taken for the roads annually, is found in the central eastern part of section 18 (16 N., 10 E.). The stripping is from 1 to 3 feet and the extent about 5,000 square yards. The size is below the average and the oxidation above.

In the southeastern corner of section 19 (16 N., 10 E.), on the land of G. Hammond, about 4 acres of a kame, which rises about 45 feet above the adjacent region, are underlain by a bed of unstratified gravel, hardpan and fine sand in about equal proportions. The depth ranges from 10 to 30 feet, and the stripping from 2 to 4 feet. The average of 2 samples of the gravel shows 15 per cent. clay, 12 per cent. fine medium sand, 13 per cent. medium sand, 15 per cent. coarse sand, 20 per cent. roofing pebble, and 25 per cent. gravel. The rock percentages are 85 limestone, 10 crystallines, 2 chert, 2 shale and 1 slate. About 1,600 cubic yards are used in the annual building and repairing of roads for 2½ miles north, 2 miles east, 2½ miles south and 2 miles west. These roads are well packed and smooth, but the high amount of clay makes them somewhat muddy in the winter. Within a radius of ½ a mile, a number of these kames are seen, which undoubtedly contain more or less gravel.

Several small deposits are found along a tributary of Little Blue River in the southwest quarter of section 29 (16 N., 10 E.). One of these is on the E. M. Hinshaw place, where a gravel of a rather fine quality is found in the bluff.

In the western part of section 33 and the eastern part of 32 (16 N., 10 E.), are a number of low parallel ridges, which are 100 feet wide, from 300 to 1,000 feet long and about 15 feet high, at the crests.

Several, which have been opened on the farms of E. Greenstreet and John McFarland, were found to be composed largely of gravel, sand and clay; and by making some investigation, with a post auger, some very fine gravel beds have been opened. These contain from 1 to 3 feet of stripping, and are from 4 to 12 feet deep. The size of the material is 10 per cent. clay, 18 per cent. fine medium sand, 10 per cent. medium sand, 20 per cent. coarse sand, 25 per cent. roofing pebble, 25 per cent. gravel and 5 per cent. boulder; the rock percentages, 85 limestone, 10 crystallines, 2 shale, 2 chert and 1 slate; and the oxidation below the average.

The material is sold at 15 cents per cubic yard, and is used in building and repairing roads for 1 mile north, 2½ miles east, 3½ miles south, and ½ mile west. These roads, in general, are in good condition.

Going east and northeast from Dunreith no other deposits except very small ones are found until the bluffs, terraces and flood plains of Flatrock Creek are reached.

In the bluffs of Flatrock Creek, on the farms of D. M. Brown, in the northeast quarter of section 36 (16 N., 10 E.), and T. S. Nugen, in the northeast quarter of section 25 (16 N., 10 E.), are some deposits, each of which underlies several acres, with from 1 to 8 feet of stripping, which rapidly increases as it gets farther from the bluff face. The depths range between 9 and 12 feet. The rock composition is about the average, the size of the material a little below, and the amount of oxidation above. From these deposits the roads are built and repaired for 4 miles east and 2½ miles west.

A similar gravel for size, rock percentages and oxidation is found in the bluffs of Flatrock Creek, from 20 to 40 feet above the stream, on the L. Butler property, in the northeast corner of section 12 (16 N., 10 E.), and the northwest corner of section 7 (16 N., 11 E.). The extent is not well determined, but it is known that for 40 rods both up and down stream from this point groundhog diggings and other excavations show more or less gravel to be present in the bluff. The depth will average about 8 feet, and the stripping from ½ to 7 feet. A section shows: (a) Stripping 2 feet, (b) gravel 8 feet, (c) clay 1 to 2 feet, (d) gravel 10 feet. This material is used on the roads for 4 miles east and 2½ miles west.

In the northwest part of section 7 (16 N., 11 E.), on the land belonging to the Shute heirs, is a small bed of gravel beneath from 1 to 2 feet of surface. The quality of the material is about the average, and it is used on the roads for 1 mile north, 4 miles east, 2½ miles west and ½ mile south.

Besides this deposit and some creek gravel in the eastern part of section 31 (16 N., 12 E.), no deposits of economic importance are known east of Flatrock Creek. The well records in general show only beds of a few feet, at most, in thickness. Since two railroads

are near at hand, the writer would suggest, for this vicinity, a crushed limestone, shipped to the most convenient railroad switch. This could probably be done for what it costs to haul the gravel for 4 miles, and when in addition to this the greater durability of the limestone is taken into consideration, it will very likely be the cheaper road metal.

DELAWARE COUNTY.

Area in square miles	395
Population in 1900	49,624
Miles of public roads	800
Miles of improved roads	600
Percentage of roads improved	75
Miles improved with gravel	600
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,000*
Total original cost of improved roads	$600,000
Annual cost of repairs per mile on gravel roads 5 years old	$100
Miles of improved roads (gravel) built in 1905	2
First improved roads built	1858
Proportion of improved roads built since 1895 (per cent.)	5
Satisfaction of farmers with investment in improved roads	Good
Authority	J. E. Davis, County Auditor

*No roads have been improved under the present law. All are township roads or abandoned toll roads. The cost of $1,000 per mile is estimated.

This county lies east of Madison, north of Henry, south of Grant and Blackford, and west of Randolph and Jay. Its shape is that of a rectangle, 21 miles long from north to south, and 19 miles wide from east to west. The northeastern fourth is crossed by the Mississinewa River, which flows in a northwesterly direction; and the central by the White River, flowing from east to west. In the channels of these streams, as well as some tributaries, the Niagara limestone, of the Silurian, comes to the surface.

Some very pronounced moraines are found in this county, from which a large portion of the gravel is obtained. The continuation of the terminal moraine of southern *Randolph and northern Henry is also found in the southern part of this county. The eastern portion is traversed by the Union City moraine, and the northeastern corner by the Mississinewa. There is a very well developed eskar, east of Royerton.

*See page 327.

The transportation is extra good. Intersecting at Muncie and extending in all directions are the Cleveland Division of the Big Four; the Lake Erie and Western; the Chicago, Cincinnati and

DELAWARE COUNTY.

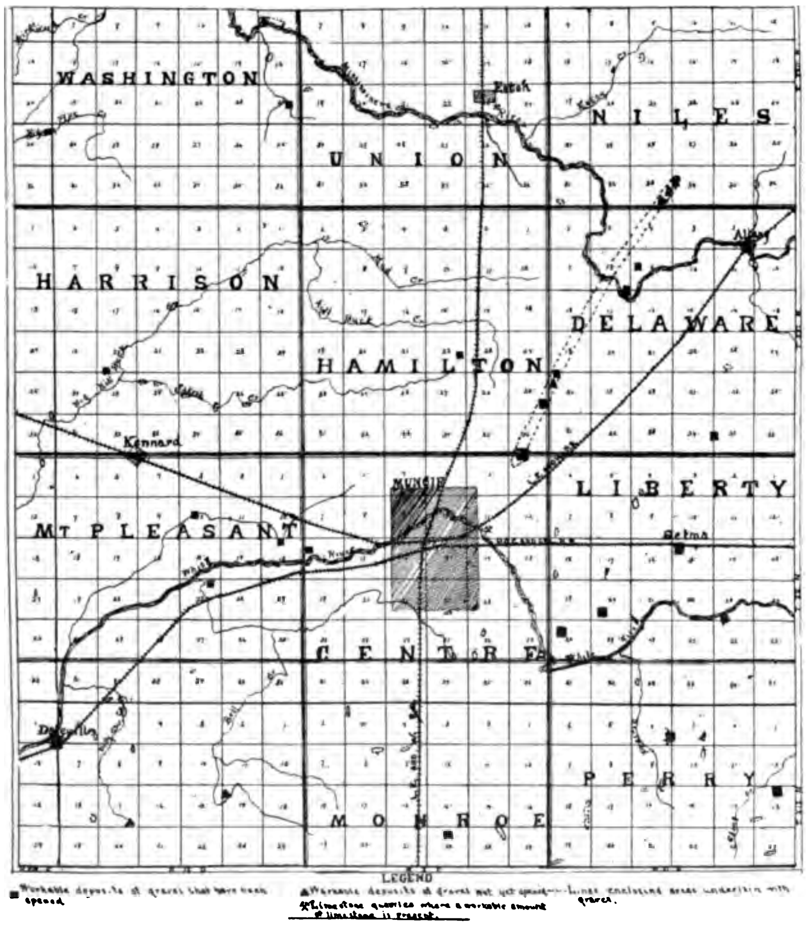

Fig. 35. Illustrating the distribution of road materials in Delaware County.

Louisville; and the Ft. Wayne, Cincinnati and Louisville. Besides these, the Chicago, Indiana and Eastern from the northwest and three interurban traction lines, two running west and one north, have their terminals in Muncie.

Although, as in counties heretofore mentioned, numerous gravel deposits are found in the bluffs, terraces and flood plains of streams, the larger per cent. of the workable deposits are located in the morainic ridges and hills. For size the morainic material has brought the average above that of central Indiana; an average sample showing 13 per cent. clay, 13 per cent. fine medium sand, 11 per cent. medium sand, 14 per cent. coarse sand, 26 per cent. roofing pebble, 20 per cent. gravel and 3 per cent. boulder. The average for rock percentages is 87 limestone, 9 crystallines, 2 shale, 1 chert and 1 slate, with a small amount of sandstone and a few other rocks.

Gravel.

The Five Southern Miles of Township 22 North, Ranges 9, 10, 11, and Part of 8 East.

This area consists of 95 square miles and is located along the northern boundary of the county. The gravel deposits are found, for the most part, along the Mississinewa and its larger tributaries, and the morainic ridge of the southeastern portion. Smaller deposits are found along Big Pipe and Kirkwood creeks in the western part.

On the farms of W. Milholand and J. W. Harris is located, in the flood plains on either side of Big Pipe Creek, in the northeast quarter of section 25 (22 N., 8 E.), a rather extensive bed of gravel below the ground-water level. Although careful tests have not been made to ascertain the exact extent or depth it is known to underlie, beneath from 2 to 4 feet of surface, at least 2 or 3 acres, and probably considerable more. The gravel is of a good quality, being unoxidized and of a fair size. The rock percentages are 80 limestone, 16 crystallines, 2 shale, 1 slate and 1 chert. Almost all of the material that is used on the roads in the western part of the civil township, Washington, is obtained by dipping from this bed.

In the northeast quarter of section 7 (22 N., 9 E.), gravel has been found beneath water level in the flood plains of Kirkwood Creek by ditching. It is reported to be of good quality.

Besides these two locations mentioned, both of which will require careful testing before any machine can be set for dipping,

no others of economic importance are known going east, until sections 12, 13 and 24 (22 N., 9 E.) are reached.

On the Frank Keplinger property in the central western part of section 12 (22 N., 9 E.), and on that of S. Richard in the central part of section 12, are gravel deposits in the bluffs and flood plains of the Mississinewa. The former bed outcrops for 20 rods up and down the river and for 200 yards back from the pit. The depth to water level is 8 feet, and the stripping is from 1/4 to 2 1/2 feet. It grades into sand at places. The second is a very limited deposit and is not workable. Its depth is 6 feet and stripping from 1 to 3 feet. The sizes of these materials are above the average, being, as is shown from the mean of three samples, 11 per cent. clay, 7 per cent. fine medium sand, 8 per cent. medium sand, 4 per cent. coarse sand, 13 per cent. roofing pebble, 49 per cent. gravel and 8 per cent. boulder. The rock percentages are 84 limestone, 14 crystallines, 1 shale and 1 chert; and the oxidation is considerably below the average. For road use the material is stony, but is very durable, and if the coarser material will be used for the base and the finer for a dressing, the roads will be smooth, hard and very satisfactory.

Below ground-water, in the flood plain of a tributary to the Mississinewa, on the Dollie Ginn place of section 13 (22 N., 9 E.), a depth of 14 feet of gravel of a fair quality is said to exist, but the extent has not been tested.

On the place of S. Miller, in the east central part of section 24 (22 N., 9 E.), is a flood plain deposit below water-level, of workable extent and depth. The stripping is 2 feet, the size average and rock percentages are 80 limestone, 16 crystallines, 2 chert, 1 slate and 1 shale. The oxidation is nothing.

All along the Mississinewa, as we advance east, workable deposits are found in the flood plains, terraces and bluffs. Much of the material is a little above the average for size. In the southwest quarter of section 22 (22 N., 10 E.), on the property belonging to Robert Smith, are about 2 acres known to be underlain with from 5 to 14 feet of gravel, beneath 2 feet of surface. The material is about average in rock composition, and is a little above in size. It is used in building and repairing for 2 miles north, 1 1/2 miles south, 1 1/2 miles east and 1 mile west.

In a kame in the southwest part of section 31 (22 N., 11 E.), a workable amount of gravel is found on the land belonging to the Dudelston heirs. This deposit of gravel, clay and sand, is covered with from 1 to 6 feet of surface, and is 35 feet deep. The material is of an average size, and has a rock composition of 84 per cent. limestone, 13 per cent. crystallines, 1 per cent. chert, 1 per cent. shale and 1 per cent. slate. The color is brown at the top and gray at the bottom, and the amount of weathering is somewhat below the average.

Along the Mississinewa in the terraces and flood plains of this civil township, Niles, large deposits are known to exist, as has been indicated by post auger holes, ditches and other excavations.

In the flood plain of a small stream on the D. B. Moore property, in the northwest quarter of section 16 (22 N., 11 E.), is a deposit below ground-water level, which, by rough tests, seems to be workable. The depth, where worked and tested, is 20 feet and the stripping 3 feet. The material is of exceptional quality for wearing and packing, the latter being due to a calcareous clay. The sizes and rock percentages are about average. 1,500 cubic yards of the material, which has been taken out with a *gravel excavator, are put onto the roads annually, for 2 miles south, 3½ miles east, 1½ miles north and 2 miles west. The distance this material is hauled to the east shows the need of road material in the northeast corner of the county. Since random tests along Estey Creek have given no further locations for setting a dipping machine, on account of too much clay, the author would suggest a careful inquiry into the endless chain process, which will wash the gravel to a certain extent, and thus can be used where the dipping machine can not be.

In the southeast and southwest quarters of section 33 (22 N., 11 E.), on the places of J. T. Black and Samuel Gregory, in a ridge extending more or less broken, southwest to Muncie, is a large deposit of gravel, sand and clay beneath from 1 to 5 feet of stripping. The length of the bed is undetermined, but seems, as has been learned by several pits and other excavations, all of which show a very similar material, to be ½ mile long and 200 feet wide. The depth, at the pit, is 30 feet. A section shows: (a)

*See page 324.

Stripping 5 feet, (b) a brown gravel somewhat below the average in size 5 feet, (c) a grayish brown gravel a little above the average for size 10 feet, (d) a gray material above the average for size 10 feet. The rock percentages are 80 limestone, 15 crystallines, 2 chert, 2 shale and 1 slate. The clay of this material, which is about 15 per cent., is a kind of fine calcareous conglomerate, which makes a most excellent packing material. The gravel, even in the pit, is so cemented together by this substance, that it comes down in great masses, which have to be broken apart. 2,000 cubic yards are used in the annual building and repairing of roads for 2 miles east, 2 miles north, 1 mile west and ½ mile south. These roads are very durable, smooth and hard.

In the western portion of section 36 (22 N., 11 E.), for about ½ mile along a tributary to the Mississinewa, the flood plain close to the stream has been tested and found to be underlain with about 10 feet of gravel which is covered by 2½ feet of surface. At three places the material has been *pumped out. The sizes are 15 per cent. clay, 10 per cent. fine medium sand, 5 per cent. medium sand, 10 per cent. coarse sand, 20 per cent. roofing pebble and 40 per cent. boulder. The rock percentages are about the average and the oxidation nothing. 700 cubic yards, at a cost of 40 cents per cubic yard, are used in the annual building and repairing of roads for 1 mile south, 1 mile east, 2½ miles north and ½ mile west. The high per cent. of clay makes the road somewhat muddy in the winter, but otherwise the material is very good.

For the northeastern corner of the civil township, Niles, where road material is hauled for several miles, the writer would suggest that investigation be made as to the cost of getting crushed stone, which is much more durable than gravel, to the nearest railroad switch. In this investigation, the results of the U. S. Road Testing Laboratory on samples of rocks from various parts of the state may be helpful.

Township 21 North, Ranges 9, 10, 11, and a Part of 8 East.

In this area of 114 square miles the greater amount of the gravel is found in the eastern portion, in the morainic ridges, and a smaller amount in the flood plains and terraces of the

Mississinewa and its tributaries, Jakes, Mud, Big Kill Buck, and Kill Buck creeks.

In the northwest quarter of section 12 (21 N., 11 E.), on the property of Kifer Crua, is a small unworkable bed of a soft gray gravel. The material being considerably below the average in size, and the bed only 4 feet deep, with 2 feet of stripping, the deposit is impracticable except for very local use.

Another small bed, which is beneath the water level, is found in the flood plain of a tributary to the Mississinewa, in the southwest quarter of section 13 (21 N., 11 E.), on the places belonging to George A. Stafford and J. A. Triddle. Since the gravel is so scarce in this locality, and the limestone, either 300 feet north or south of this location, is within 2 feet of the surface, it would probably pay to set a small portable *crusher.

In a low morainic ridge on the land of James Dill, in the southwest quarter of section 23 (21 N., 11 E.), is a bed of gravel beneath ground-water level which has where tested a maximum depth of 18 feet and a minimum of 7 feet. The extent has not been determined, and the quality is reported to be very good.

Six or 7 acres, which include 5 or 6 kames, on the Thomas Ore place, in the west-central part of section 35 (21 N., 11 E.), were found to be underlain by gravel, sand and clay. The pit walls, on which 2,000 square yards are exposed, show a depth of from 18 to 38 feet and no bottom; a stripping of from 2 to 7 feet, and a continual grading of the gravel, sand and clay into one another, 3-6 being gravel, 2-6 sand and 1-6 clay. The size of material, rock composition and oxidation are about the average for the gravel. One thousand six hundred cubic yards at a cost ranging between 15 and 20 cents are used in the annual building and repairing of the roads for 2 miles north, 3 miles south, 6 miles east and ½ mile west. These roads are hard, smooth, durable, and give good satisfaction.

On the farms of George A. Stafford and R. F. Brammer, in the west-central part of section 9 (21 N., 11 E.), is a workable bed of gravel and sand above ground-water level which has a stripping of 3 feet and a depth of 18 feet. If the many lenses of sand occurring in the bed can be worked around or screened off

*For output and cost of crushing see page 327.

the rock percentages will be average and the size a little above. The color ranges from gray at the bottom to brown at the top, and the oxidation about average. The material is used on the roads for 4 miles east, ½ mile north, ½ mile south, and ½ mile west.

On the first terrace above the flood plain and in the flood plain of the Mississinewa River, in the central part of section 16 (21 N., 11 E.), on the land belonging to Joseph Joegodlove, are about 20 acres underlain by gravel, as has been learned by post auger holes and other excavations. At the pit on the terrace there is a depth of 15 feet and a stripping of 2 feet. The size of the material is a little above the average. The material of the flood plain would have to be dipped, which would hardly pay where such a large quantity of good gravel, above water level, is available.

In the continuation of the same glacial ridge which stands out very conspicuously above the adjacent country and in which the large deposits on the Samuel Gregory farm in section 33 (22 N., 11 E.) occurs are found numerous deposits in this congressional township. A few of these places have been opened on the farms of L. Adams, in the southwest quarter of section 19 (21 N., 11 E.); Wilson, Payton and Reid, in the southeast quarter of section 25 (21 N., 10 E.), and Mrs. Thomas Pacy, in the southwest quarter of section 36 (21 N., 10 E.). The rock compositions being about the average for the county, there being no bottom found other than gravel, and a very abrupt grading of the gravel into fine sand and clay, are common characteristics of all.

At the Adams pit, the stripping is 2 feet, depth 18 feet, and the size a little below the average. The Wilson, Payton and Reid pit shows from 1 to 5 feet of stripping, a depth of 20 feet, and a size considerably below the average, being 8 per cent. clay, 18 per cent. fine medium sand, 20 per cent. medium sand, 25 per cent. coarse sand, 14 per cent. roofing pebble, 13 per cent. gravel, and 2 per cent. boulder. In the vicinity of the Pasy pit, the ridge becomes very pronounced, being about 70 feet high, 200 yards wide, and having a hummocky topography. The depth at this place is from 7 to 18 feet, and the stripping is 1 foot at the crest of the ridge, but increases to 6 feet 150 feet from the crest along the slopes. This difference in stripping is due to the transporting and depositing of the slope wash during heavy rains.

The mean of two samples gives the following sizes: 12 per cent. clay, 7 per cent. fine medium sand, 8 per cent. medium sand, 14 per cent. coarse sand, 13 per cent. roofing pebble, 36 per cent. gravel, and 10 per cent. boulder.

The amount of gravel that can be obtained from this morainic ridge in this congressional township will probably be several hundred thousand cubic yards. For durability, it is about an average, but the high content of clay generally makes the roads rather muddy in the winter and dusty in the summer.

In a gentle raise in the southeast quarter of section 22 (21 N., 10 E.), on the farms of Joseph Sheets and Joseph Pattenger, is a bed of gravel which underlies about 3 acres with a depth ranging between 6 and 11 feet and no bottom found, and a stripping of from 1 to 3 feet. The size, rock composition and amount of weathering are about average. This material is used in building and repairing roads for 3 miles north, 3 miles west, 2 miles south, and 2 miles east.

In a low hill on the property belonging to a Mr. Turner, in the northeast quarter of section 16 (21 N., 10 E.), is a bed of gravel underlying, as rough tests indicate, about 1½ acres, with a depth of 15 feet and a stripping ranging between 4 and 8 feet. The rock percentages are about average and the size a little above. It is used on the roads for 3 miles north, 2 miles east, 2 miles south, and 3 miles west, and gives good satisfaction.

Between the central and north-central parts of section 5 (21 N., 10 E.), on the David Rench land, is an unstratified bed of gravel, clay and sand in a morainic hill which underlies about 2 acres. The depth at the pit is from 8 to 12 feet and the stripping ranges between 1 and 6 feet. The rock composition is the average, and the size is above, with about 14 per cent. of clay.

In the flood plain of Mud Creek, beneath from 2 to 3 feet of surface, on the farm of Mary L. Garrard, in the south-central part of section 6 (21 N., 10 E.), is a bed of gravel apparently underlying 3 or 4 acres, as is indicated by two pits 250 yards apart, and other tests. The depth is from 8 to 9 feet. The rock composition is about average, the size above, and the oxidation below. One thousand two hundred cubic yards are used in the

annual repair and building of roads for 1½ miles north, 1½ miles east, 1½ miles south, and 4½ miles west. The material is durable and makes a smooth and hard road.

In the flood plain of Big Kill Buck Creek, on the farms of William Benidum, in the southwest quarter of section 11 (21 N., 9 E.), and J. W. McCreary, in the northeast quarter of section 16 (21 N., 9 E.), are beds of gravel beneath water level, with a depth where tested of 25 feet. The extent is not known.

Possible locations for dipping, which have not been tested as to depth or extent other than to know that gravel exists beneath the ground-water level, are found in the flood plains and terraces of Jakes Creek on the farms of Isaac Brinhall in the southwest quarter of section 26 (21 N., 9 E.); of George McWilliams, in the east-central part of section 27 (21 N., 9 E.); of Sarah Smith, in the southeast quarter of section 27 (21 N., 9 E.); of Samuel Lee, in the northwest quarter of section 27 (21 N., 9 E.); of B. Miller, in the northeast quarter of section 28 (21 N., 9 E.), and of Polk Fuller, in the northwest quarter of section 28 (21 N., 9 E.).

On the gentle valley slope of Big Kill Buck, 120 yards from the stream, are 3 or 4 acres underlain by gravel, as shown by rough tests, on the farm of Samuel Bell, in the southwest quarter of section 20 (21 N., 9 E.). The depth of the bed is 11 feet and the stripping is 3 feet. The sizes of the material are 12 per cent. clay, 18 per cent. fine medium sand, 10 per cent. medium sand, 10 per cent. coarse sand, 15 per cent. roofing pebble, 30 per cent. gravel, and 5 per cent. boulder. The rock percentages are about the average for the county. At a cost of 25 cents per cubic yard this material is used in building and repairing roads for 3 miles north, 2½ miles west, ½ mile south, and 2½ miles east.

Township 20 North, Ranges 9, 10, 11, and Part of 8 East.

In this area of 114 square miles are a large number of small deposits along Mud Creek, Big Kill Buck, White River and its tributaries, and some glacial ridges in the eastern portions.

Along a tributary to Big Kill Buck, in the northeastern quarter of section 1 (20 N., 8 E.), on the place belonging to I. Perry, is a small bed of gravel, beneath from 1 to 4 feet of surface, which

has a depth of 7 feet. The rock percentages and sizes of material are about the average, except that 20 per cent. is clay, which makes the roads on which this gravel is used muddy in the winter and dusty in the summer.

In the bank of Mud Creek 2 or 3 acres are underlain by gravel, sand and clay in the northwest quarter of section 10 (20 N., 9 E.), on the George McKinley property. The depth is 21 feet at the pit and the stripping from 2 to 4 feet. The rock composition is about an average for the county, and the size is below the average. One thousand two hundred cubic yards, at a cost of 25 cents per cubic yard, are put on the roads annually.

Probably 25,000 cubic yards of gravel are available on the J. R. Compton land in the northeast quarter of section 22 (20 N., 9 E.). The amount of surface underlain is about 1 acre, the depth is 21 feet and the stripping is 4 feet. The rock composition is average and the size of material is a little below.

A large deposit of gravel is found in the bluff of Mud Creek, 200 yards from the stream, on the farm of Stanley Russey, in the northwest quarter of section 13 (20 N., 9 E.). The area underlain is about 4 acres, as is indicated by the exposure of a 200 square yard cross section, a well at a house 300 yards away that is in 22 feet of gravel, and post auger holes.

The stripping at the pit is from 1 to 3 feet and the depth is 10 feet. The rock percentages are average, the size is above, and the oxidation below. One thousand two hundred cubic yards at 25 cents per cubic yard are used in the annual repair and building of roads for 5 miles north, ½ mile east, ½ mile south, and 1 mile west. These roads are hard, smooth and durable.

In the northeast corner of section 25 (20 N., 9 E.), on the place of Nathan Williams, is a bed of gravel beneath from 1 to 6 feet of surface, with an average rock composition and size of material. The extent and depth were not learned by the writer.

A deposit which is likely workable is found in a bluff of White River on the property belonging to Mary Allison, in the northwest quarter of section 18 (20 N., 10 E.) Three hundred square yards of material are exposed on the pit walls, which show a depth of 10 feet, a stripping ranging from 2 to 8 feet, a rock composition of about the average, with 14 per cent. of clay, a size

of material which is below average, and an amount of oxidation that is above. Roads on which the material has been used are dusty in the summer and rather muddy in the winter.

On the Joseph Sutton land in the southwest quarter of section 32 (20 N., 9 E.), is one of a number of kame deposits that are found in this vicinity. The material is of average quality, with exception of a high content of clay. It sells for 10 cents per cubic yard and is hauled but a short distance because of other pits.

In the northwest corner of section 1 (20 N., 10 E.), on the farms of W. Sherry and J. Doggeth, are pits in the prominent morainic ridge which extends northeast from near Muncie. At these pits the material is high in fine medium sand, which is salable at this location for concrete work in Muncie. The amount of stripping is 5 feet and the depth is 20 feet. The sizes for the latter pit are about the average and for the former below.

A small deposit above ground-water level is found in the south-central part of section 22 (20 N., 10 E.), on the property belonging to C. R. Wall.

In the south-central part of section 27 (20 N., 10 E.), on the Oliver McConnell land, beneath 2 feet of stripping, is a small deposit of gravel, clay and sand all commingled, which has a depth of 8 feet. Because of inavailability and a high per cent. of clay this material has a very local use.

About 3 or 4 acres on the Sherman Whitney place in the southwest corner of section 26 (20 N., 10 E.), are underlain by a bed of gravel having from 4 to 8 feet of stripping and a depth of 18 feet. This is a morainic deposit and the material is unstratified, with a high amount of clay, which makes muddy roads in the wet season. Otherwise the material is of a good size and little weathered. The rock percentages are almost average.

Several small locations are found on and near the W. M. Heaton farm, in the northwest quarter of section 26 (20 N., 10 E.). The depth at an old pit is 12 feet and stripping 1½ feet. The material is about the average for rock composition and a little below for size. The color is brown and the oxidation high.

Three or four acres in the flood plain of the White River in the southeast quarter of section 25 (20 N., 10 E.), are underlain

beneath $2\frac{1}{2}$ feet of surface, with a bed of stratified gravel, which has been worked to a depth of 12 feet and no bottom found. The rock composition, size of material and oxidation are about the average, with exception of only having 6 per cent. of clay. The roads on which this gravel is used are smooth and durable.

On the place belonging to Jane Cecil, in the northwest quarter of section 30 (20 N., 10 E.), are beds of gravel in kames which beneath from $\frac{1}{2}$ to 3 feet of surface underlie about 2 acres, as rough tests, such as post auger holes and the withering of crops in dry weather, indicate. This gravel often grades into sand and clay. At the pit the depth is 10 feet and the size of material and rock composition are about an average. This material packs well and is durable.

On the Ray Cecil farm in the southwest quarter of section 20 (20 N., 10 E.), is a bed of gravel and sand, with about 1 foot of stripping and a depth of 15 feet. From the pit walls and places tested back from the pit, about 3,500 square yards seem to be still underlain with either sand or gravel. The size of the gravel is above the average, but the rock percentages are 82 limestone, 15 crystallines, 2 shale, and 1 chert.

By screening, a workable amount of gravel may be found on the side of a stream valley in the southwest part of section 7 (20 N., 11 E.), on the property belonging to John Truett. At the pit the stripping is 2 feet, depth from 6 to 20 feet, rock composition and size of material about average, and color brown and yellow. Abrupt grading into sand is very characteristic.

In the northwest quarter of section 9 (20 N., 11 E.), on the property of J. Puntney, beneath from 2 to 6 feet of surface, is an area of about 1 acre underlain with gravel and sand, as has been learned by several excavations. At the pit the depth is 10 feet, the rock composition and size of material are about average, and the color is brown. To determine the exact amount of gravel and sand, tests by pipe driving or some other means will be necessary.

In the southwest corner of section 23 (20 N., 11 E.), and the northwest corner of section 26 (20 N., 11 E.), is a gravel bed beneath 1 to 3 feet of surface, which has a rock composition of

about the average and a size of material considerably below. The color is brown and the weathering considerable. The extent and depth are not known.

Northern Four Miles of Township 19 North, Ranges 9, 10, 11, and Part of 8 East.

This area of 76 square miles, which has a length from east to west of 19 miles and a width from north to south of 4 miles, lies along the Henry County boundary. Its gravel deposits, which are of economic importance, are found for the most part in morainic hills and ridges. Only small beds are known to occur in the bluffs, terraces and flood plains of streams.

For 1/4 of a mile along a small creek in a ridge in the north-central part of section 13 (19 N., 11 E.), is a bed of gravel, sand and clay which has been dug into at various points. On the farm of Jane Mills, in this ridge, is a pit which shows from 2 to 7 feet of stripping and a depth of 30 feet. The mean of two samples gives the average for the county with exception of 15 per cent. clay, and the rock composition is also about average. The color is from gray to brown, and the amount of weathering a little below the average. One thousand cubic yards are used in the annual repair and building of roads for 3 miles east, 2 miles south, 2 1/2 miles west, and 2 1/2 miles north. Otherwise than making the roads somewhat muddy in the wet season and dusty in the dry it gives good satisfaction.

On the farms of L. Doddy, in the southeast and that of George Keisling in the southwest quarter of section 3 (19 N., 11 E.), and W. Sissel in the southeastern corner of section 4 (19 N., 11 E.), are workable deposits of gravel which alternate with sand and clay. They all, when the sand is screened off, have an average rock composition, an average size of material, with exception of 14 per cent. clay, and a brown color. The first has a depth of 11 feet and the second 15 feet.

Along a stream in the northwest quarter of section 9, on the Jacob Reese place, and in the southeast corner of section 9 and the northeast corner of section 16 (19 N., 11 E.), on the Lewis Keisling farm, are several very fair locations for gravel pits.

These have been tested with post augers and other excavations and are said to contain a good quality of material.

In some morainic hills and ridges beginning in the northeast corner of section 19 (20 N., 11 E.), on the P. H. Chatman farm, and continuing north along the eastern border of section 18 (20 N., 11 E.), through the R. Felton, Jr., R. Felton, Sr., M. Carmichael, and the C., H. & D. Ry. Co. farms, are some large deposits of gravel. At all places where openings have been made, the gravel grades from a brown at the top to a grayish brown 7 or 8 feet lower. On the P. H. Chatman place, a small pit shows a depth of 5 feet and no bottom, and the following sizes of material: Eight per cent. clay, 15 per cent. fine medium sand, 20 per cent. medium sand, 30 per cent. coarse sand, 15 per cent. roofing pebble, and 12 per cent. gravel. The depth on the Felton, Jr., place is 7 feet, Felton, Sr., 8 feet, Carmichael 10 feet, and C., H. & D. 30 feet. In none of these cases, except the last, has the bottom to the gravel been found, and the deposit at no place, except at the last mentioned, has been thoroughly opened or tested, but as numerous excavations indicate, several hundred thousand cubic yards may be obtained in this vicinity. Of course, there will be some clay and sand to contend with, but this probably can be screened and worked around. The walls of the C., H. & D. pit alone show over 1,000 square yards of material which is as coarse or coarser than the average.

In kames on the farms belonging to George Gibson, of the southeast part of section 14 (19 N., 10 E.), and James Deaver, of the northeast corner of section 23 (19 N., 10 E.), are over 100,000 cubic yards of gravel, mixed more or less with sand and clay. At a pit on the Gibson place the stripping is from 1 to 3 feet and the depth 25 feet. Several acres of the hill are known to be underlain by either gravel or sand. The color of the material is brown to gray, and the sizes are 6 per cent. clay, 15 per cent. fine medium sand, 20 per cent. medium sand, 25 per cent. coarse sand, 30 per cent. roofing pebble, 3 per cent. gravel, and 1 per cent. boulder. The rock percentages are 85 limestone, 11 crystallines, 2 shale, and 1 chert. At the Deaver pit the stripping is from 1 to 3 feet and the depth 30 feet, but 200 yards from the pit, in the same hill, of 8 or 9 acres, is 12

feet of stripping and 40 feet of gravel. Also at other places on the hill the gravel is known to underlie the surface. The sizes of material are 6 per cent. clay, 8 per cent. fine medium sand, 8 per cent. medium sand, 15 per cent. coarse sand, 30 per cent. roofing pebble, and 33 per cent. gravel. The rock percentages are 82 limestone, 16 crystallines, and 2 shale. Six hundred cubic yards, at a cost of 25 cents per yard, are used in the annual building and repairing of roads for 1½ miles north and ¼ mile east. These roads are hard, smooth, and are more durable than the average. A bottom to the gravel has been found at neither of the pits.

In the northeastern and north-central parts of section 17 (19 N., 10 E.), are morainic deposits on the places of S. Flemming and a Mrs. Flemming, where, as various openings indicate, 60,000 cubic yards of gravel could probably be obtained by working around hardpan and sand masses. The rock composition is about average and the size a little above.

Probably 2 acres, with a stripping of 6 feet at a minimum, are underlaid with gravel in the northwest corner of section 4 (19 N., 10 E.), on the property belonging to William Drisco. The bed is 8 feet thick, resting on a fine sand bottom. The size of material and rock composition are about the average. One thousand five hundred cubic yards, at a cost of 25 cents a yard, are used in the annual repair and building of roads for 2 miles south, 2 miles north, 3 miles east, and 1¼ miles west. This material, with its heavy stripping, would be inavailable if it was not for a scarcity of gravel to the north, east and west.

In the northeast corner of section 8 (19 N., 10 E.), on the Marion Tuttle farm, is reported a good quality of gravel with a light stripping. Nothing was learned as to extent or depth.

A bed of gravel, with only a few feet above water level and an insufficient depth beneath for dipping, is found beneath 4 feet of stripping on the land of Jacob Reynolds, in the south-central part of section 6 (19 N., 10 E.). The writer would suggest that tests be made for the endless chain, which can be set for a shallower bed than a gravel excavator.

Gravel is found in morainic hills on the Irving Moffett place in the south-central part of section 2 (19 N., 9 E.), and that of

Perry Stewart, in the northwestern part of section 11 (19 N., 9 E.). A pit at the latter shows a depth of 8 feet with a clay bottom, and a stripping ranging between 2 and 5 feet. The size of the material is above average and the color is brown. The amount is workable, but the inavailability makes it rather impracticable.

In a lower terrace of a stream in the southwest corner of section 14 (19 N., 9 E.), on the land belonging to the Cromer heirs, is a bed of gravel which is under from 1 to 5 feet of soil, and has no bottom other than water. Tests have been made for a few feet beneath water level, and it is possible that a location for dipping can be found. The size of the material is average and the color above water level is brown. It is used in building and repairing for 3 miles west, 2 miles south, 2 miles east, and 2 miles north, and is found to make a durable road.

Beneath from 2 to 4 feet of surface and with a depth of 10 feet where known are beds of gravel located in a morainic deposit in the southeastern corner of section 17 (19 N., 9 E.), on the farm of P. Shoemaker, and in the northeastern corner of section 20 (19 N., 9 E.), on the Cyrus Van Matre property.

Rough tests indicate about 4 acres to be underlain by the gravel, sand and clay which grade into one another. At pits on both places the rock composition is found to be about average and the sizes of material a little above.

Deposits, which are not tested as to depth or extent, are found in the east-central part of section 24 (19 N., 8 E.), on the land belonging to Joseph Prigg; in the southeastern corner of section 18 (19 N., 9 E.), on the John Branon farm; and on the place of Henry Moreland, in the northeast corner of section 8 (19 N., 9 E.).

Morainic ridges and kames are found in sections 5 and 6 in which there are a number of workable deposits. Among these are those on Joseph Myers' place, in the southeastern corner of section 6 (19 N., 9 E.); on that of John May, in the north-central portion of section 5 (19 N., 9 E.), and on the farm belonging to Carrie Fenwick, of the northwest quarter of section 5 (19 N., 9 E.). On the May place, the pit walls show from 2 to 7 feet of stripping and a depth of 12 feet of gravel. The size and quality of the material is about average.

LIMESTONE.

Limestone comes to the surface at numerous places in the beds of White River and the Mississinewa, and somewhat in the larger tributaries. The rock is generally hard and has a light buff color.

In the eastern part of Muncie is located two small crushing plants. The larger, which is located at the Mock stone quarry, crushes on an average 100 cubic yards daily. This material is used for the most part on the streets of Muncie. A section at this quarry is as follows:

Section at the Mock Quarry in East Muncie.

		Feet.
1.	Yellowish gray, ferruginous, and thin bedded limestone	4
2.	Gray, thin bedded, fragmental, and somewhat argillaceous limestone	3
3.	Blue, fragmental limestone	3
4.	Gray, thick bedded, somewhat ferruginous limestone	8

Nos. 1 and 2 are inferior to 3 and 4, being softer and more brittle. The beds of No. 2 are from 2½ to 5½ feet thick.

The amount of this material available will without doubt reach several hundred thousand cubic yards.

Another small crushing plant, where the output is 100 cubic yards per day, is located in the southeastern part of Eaton, at the Eaton stone quarry. At this plant 25 men are employed for 6 months of the year.

A section at the quarry shows the following:

Section at the Eaton Quarry.

		Feet.
1.	Yellow to red and weathered limestone	6
2.	Porous, hard, and blue limestone	34

The beds of No. 2 vary from 1 to 14 inches in thickness, and are free from clay. This stone, where used in the vicinity of Eaton, is giving very good satisfaction, being much more durable than the gravel.

MADISON COUNTY.

Area in square miles	460
Population in 1900	70,470
Miles of public roads	900
Miles of improved roads	325
Percentage of roads improved	36.1
Miles improved with gravel	325
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$3,500
Total original cost of improved roads	$1,137,500
Annual cost of repairs per mile on gravel roads 5 years old	$95
Miles of improved roads (gravel) built in 1905	$14\frac{3}{8}$
First improved roads built	1862
Proportion of improved roads built since 1895 (per cent.)	16
Satisfaction of farmers with investment in improved roads	Good
Authority	Jos. D. Kinnard, County Auditor

Madison County, with Anderson as its county seat, lies south of Grant, west of Delaware and Henry, north of Hancock, and east of Hamilton and Tipton Counties. Its surface is, in the main, an undulating till plain. White River, which with its numerous tributaries, drains the northern three-fourths of the county, traverses the southern half from east to west.

Three geological periods are represented in the surface rocks of this county, viz., the Niagara limestone of the Silurian, the Pendleton sandstone of the Devonian, and the glacial drift of the Pleistocene. The Niagara limestone outcrops at numerous places in stream beds, some of which are found *200 yards below the falls at Pendleton; on the north bank of Fall Creek north of Alfonte; at a quarry two miles west of the Anderson courthouse; and near Frankton on Pipe Creek. The Devonian sandstone occurs *in the lower edge of Pendleton, at the foot of the fall. The drift is the compact till, sand and gravel that cover the bed rocks of the county.

The transportation facilities of the county are good. The Michigan Division of the Big Four crosses it from north to south; the P., C., C. & St. L. from the northeast to the southwest; the Chicago and Southeastern, near the center, from east to west; and the L. E. & W. the northern third, from east to west.

For quality of gravel, Madison County is about the average

*Rep. Geol. Surv. Ind., 1903, page 426.

MADISON COUNTY.

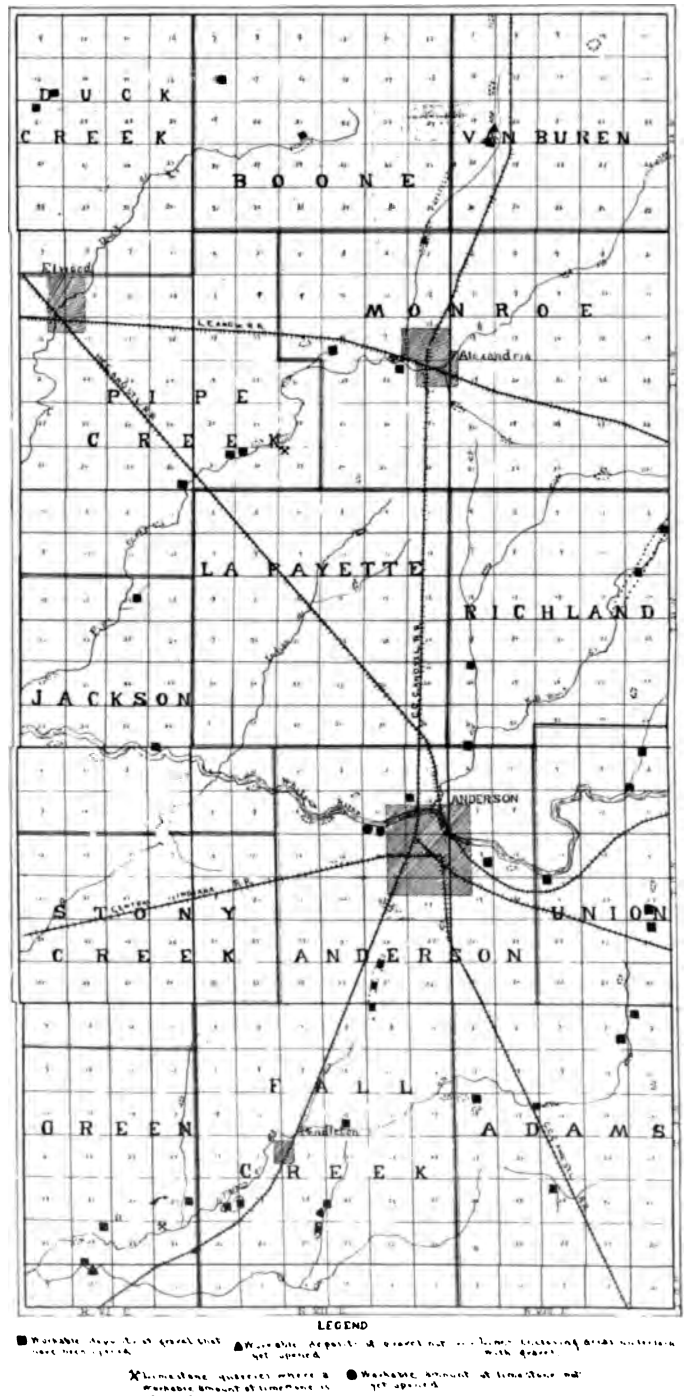

Fig. 36. Illustrating the distribution of road materials in Madison County.

for central Indiana, but in amount is below. For limestone, on the other hand, it ranks among the very first in both quality and amount. The principal deposits of gravel are found in the bluffs, terraces and flood plains of the main streams, such as White River, Killbuck, Fall and Pipe creeks; in the morainic ridges and hills, such as those south of Anderson three miles and those west of Chesterfield; and in the old valleys in the vicinity of Summitville, that have been deeply filled with drift and are now entirely obscured.

The average sizes for the gravel are 10 per cent. clay, 15 per cent. fine medium sand, 15 per cent. medium sand, 19 per cent. coarse sand, 22 per cent. roofing pebble, 17 per cent. gravel, and 2 per cent. boulder. The average rock percentages are 84 limestone, 10 crystallines, 2 shale, 2 chert, and 2 slate.

Gravel.

Northern Five Miles of Township 22 North, Range 7 and Parts of 6 and 8 East.

With the exception of the deposits in the old filled up valleys and the terraces and flood plains of Duck Creek, there are no workable deposits in this township.

In an old pre-glacial valley, that has been filled up with gravel, sand and clay, and in which Pipe Creek has cut its channel, are gravel beds below the water level on the farms belonging to J. W. Hammilton, in the northeast quarter of section 26, and J. Ellsworth, in the northwest quarter of section 35 (22 N., 8 E.). The bed on the former place was tested to a depth of 35 feet and no bottom to the gravel was found.

A small quantity of a very sandy gravel is found on the J. and S. Eccles place, in the southwest quarter of section 10 (22 N., 8 E.). Another deposit, which is said to be below ground-water level and to underlie 10 acres, is found on the C. M. Leach place of the same quarter section.

Commencing in the northeast quarter of the northeast quarter of section 7 and extending south to the northeast quarter of the northeast quarter of section 18, and here forking, the one fork extending in a general westerly direction for 1 mile and the other

east into the central part of the northwest quarter of the northwest quarter of section 17 and then south near the border line of sections 17 and 18, until the northern parts of sections 29 and 30 (22 N., 8 E.) are reached, where a southeasterly course is taken to the central part of section 36, is an old stream valley 1/4 mile wide, and its tributaries, that have been so completely filled up with gravel, sand and clay that all original topographical characteristics have been lost. At numerous locations general tests have indicated that the gravel is in sufficient quantities to be of economic importance. Some of these locations, where pits have been operated, are found on the H. Trader land of the northeast quarter of section 7, the H. Tomlinson and the E. Payne places of the northeast quarter of section 18 (22 N., 8 E.), on those of H. E. Vinson and F. Vinson of the southeast quarter of the same section, O. Griffe, W. Roseboom, A. Roseboom, and D. W. Webster of western Summitville, H. McClain of the northeast quarter of section 25, and A. E. Harlan of the southeast quarter, and W. A. Ellsworth of the northeast quarter of section 36 (22 N., 7 E.). With exception of the first three pits, which are above the groundwater level, all are below water level. At the Roseboom pit the depth is 25 feet, stripping 3 feet, and extent workable. The depth at the Webster has been found to be 30 feet, the stripping 3½ feet, and the extent workable.

The average of three samples which were obtained from the O. Griffe, W. Roseboom, A. Roseboom, and D. W. Webster pits, shows the following sizes of material: Thirteen per cent. clay, 12 per cent. fine medium sand, 7 per cent. medium sand, 12 per cent. coarse sand, 23 per cent. roofing pebble, 29 per cent. gravel, and 2 per cent. boulder. The rock percentages are 82 limestone, 13 crystallines, 3 shale, 1 chert, and 1 slate.

The amount of clay, which causes the material to pack quickly and keep its place on the road, and the unoxidized condition, makes this one of the best road building gravels of the county. It is used on the roads for 3 miles north, 2 miles west, 3 miles east, and 3 miles south.

When a series of systematic tests have been made in this old valley, undoubtedly a large amount of material that at present is unknown will be found. Where the clay is found to be too great

or the depth insufficient for the *gravel excavator, the endless chain apparatus should be carefully considered. Although it will not lift out as much material in a day, it can be operated at a lower expense, and washes out a portion of the clay and dirt.

Along Duck Creek in the south central part of section 21 (22 N., 7 E.), on the farms of M. J. Sullivan and J. C. Hull, two locations have been found for setting a gravel excavator, and by general tests 2 or 3 acres to be underlain with gravel. At the pit, where gravel has been thrown out, the depth is 20 feet and no bottom found, and the stripping 3 feet. The rock percentages are 74 limestone, 19 crystallines, 3 shale, 3 chert, and 1 slate; and the sizes of the material are 8 per cent. clay, 12 per cen. fine medium sand, 20 per cent. medium sand, 25 per cent. coarse sand, 25 per cent. roofing pebble, 9 per cent. gravel, and 1 per cent. boulder.

Along this same stream gravel is known to occur beneath ground-water level, on the W. Tomlinson property in the north-central part of section 28 (22 N., 7 E.). The bottom of a ditch for several rods is found to be in gravel, below ground-water level, on the J. W. Call place in the northwest quarter of section 10 (22 N., 7 E.). A small deposit of gravel is found in the south-central part of section 34 (22 N., 7 E.), on the G. Carver land. The extent of the bed is small and shallow.

Below the water level in the central part of section 18 (22 N., 7 E.), on the property belonging to W. Townsend, a workable amount of gravel is found beneath 8 feet of stripping. The depth of the deposit is 10 feet, and rock composition and sizes of the material are about average. Only because of a great scarcity of road material in this neighborhood can such an inavailable deposit be considered practicable.

Located under 3 or 4 acres of low ground and beneath the ground-water level, with from 4 to 7 feet of stripping, are workable gravel beds in the southeast quarter of section 16 on the Frank Leisure place, and on that of P. Shay, in the northwest quarter of section 21 (22 N., 6 E.). These rest upon clay bottoms; the former has a thickness varying between 4 and 15 feet, and the latter about 15 feet. The quality of the material is about average in both size and rock composition. The amount

*See page 324.

of weathering is almost nothing. Pronounced gradations between the gravel, fine sand and clay are often met, and only by very careful testing can locations be found for taking the gravel out.

For the parts of this township where gravel is being hauled 2½ or 3 miles, it will be well to consider the availability and cost of obtaining crushed limestone, which is far more durable than the gravel. At both the Abbott quarry, 1½ miles northeast of Frankton, and the Nicoson quarry of West Alexandria, very fair qualities of rock for road building purposes are found.

Township 22, Range 7 and Part of 6 and 8 East.

In range 6 of this township very few gravel beds of economic importance are found. The only two being used are in the northeast quarter of section 28 on the Henry Myerly farm, and on that of A. and L. Funkhouse, in the southeast quarter of section 36. The former bed, which is in the Duck Creek flood plain, rests on a clay bottom, is 11 feet thick at the pit, 7 of which is above groundwater level and 4 below, and has a stripping of 2 feet. Three acres of the flood plain has been hastily tested and are known to be underlain by gravel and sand. The latter bed has from 1 to 3 feet of stripping, a thickness at the pit of 13 feet, and underlies 2 or 3 acres, as has been learned through very general tests. The rock percentages of both of these gravels are about the average, and the sizes of the material for the first are about average, and for the second above. Both deposits are of good quality, but the merging into sand and clay makes the regions questionable as to amount of available gravel.

In the bluffs of Pipe Creek, on the farms of Alexander Wise and C. and N. Quick that are in the northeast quarter of section 31 (21 N., 7 E.), and the northwest quarter of section 32 (21 N., 7 E.), is a bed of gravel that gives a cross section of 300 by 4 yards in the pit wall. By various tests it is known to extend back for at least 50 yards from this wall, thus giving a possible content of 60,000 cubic yards. No bottom has been found to this bed, and the stripping is from 1 to 3 feet. In some places the gravel merges into fine sand. The sizes of the material are 8 per cent. clay, 10 per cent. fine medium sand, 12 per cent. medium sand, 18 per cent. coarse sand, 20 per cent. roofing pebble, 31

per cent. gravel, and 1 per cent. boulder. The rock percentages are 88 limestone, 8 crystallines, 2 chert, and 2 slate. The oxidation is about average. This material is used for 5 miles north in the annual building and repairing of roads which, where the grading and ditching at the sides have been properly done, are smooth, hard and durable.

A workable amount of gravel is found in the bluffs of Pipe Creek on the farm belonging to Daniel Abbott, in the southwest quarter of section 28 (21 N., 7 E.). This bed is known to follow the bluff 200 yards and to extend back from it as much as 100 yards, but with a great increase in stripping. The stripping at the bluff face where the pit is located is 2 feet, the depth is 12 feet, and the bottom is clay. The rock composition is average, and the sizes of the material are 12 per cent. clay, 10 per cent. fine medium sand, 5 per cent. medium sand, 10 per cent. coarse sand, 15 per cent. roofing pebble, 40 per cent. gravel, and 8 per cent. boulder. Because of the proper amount of clay and coarseness this material makes a durable road.

Along the same stream, on the John Little land in the southwest quarter of section 21 (21 N., 7 E.), is a deposit of gravel with similar physical characteristics to that on the C. H. Gipe place. This material is used for 6 miles to the north.

On the farm of C. H. Gipe, in the northwest quarter of section 22 (21 N., 7 E.), is a workable bed of 50 per cent. fine sand and 50 per cent. gravel. No bottom has been found, the depth is 15 feet, and the stripping from 2 to 6 feet. The rock composition, sizes of material, excepting fine sand, and amount of weathering are about average.

A similar deposit is found on the adjacent farm to the west belonging to G. H. Smith. Here the gravel and fine sand are known to underlie 8 or 9 acres. The many sudden gradations of the gravel to fine sand requires careful testing before opening a pit.

Beneath from $2\frac{1}{2}$ to 4 feet of stripping in the flood plain of Pipe Creek on the place of Albert Gordon, in the south-central part of section 3 (21 N., 7 E.), is a bed of gravel which has been tested to a depth of 16 feet at a number of places over an area of 10 acres and no bottom found. The material in both size and rock composition is almost average. About 2,000 cubic yards are

used annually in building and repairing roads for 2 miles north and 3 miles west. These roads, where properly attended to, are smooth, hard and durable.

In the flood plain of a small valley, beneath water level, is a bed of gravel on the farms belonging to R. R. Beck and W. Cooper, in the southeast quarter of section 34 (21 N., 7 E.). On this location tests were made with an auger at two points 12 rods apart which showed 4 feet of stripping and 4 feet of gravel, no bottom being reached. About 15 rods from a line connecting these two tests is a ditch with its bottom in the gravel for several rods. This location is one that should be carefully tested, because of the great scarcity of gravel in this vicinity.

In the northwest quarter of section 1 (21 N., 7 E.), on the W. Heritage and Samuel Phillips farms, in an old filled up valley with a width of 1/4 mile, are locations for dipping beneath from 3 to 7 feet of stripping and with depths of 35 feet. No bottom has been found. The stripping is found to increase rapidly as it gets away from the center. The extent is known to be large, several acres having been tested in a general way and no limits to the deposit found. The rock composition is about the average, but the sizes of the material are a little below. Twelve per cent. being clay, together with the unoxidized condition, makes this a very desirable material for road building and repairing.

In the southeast quarter of the southeast quarter of section 24 (21 N., 7 E.) and the southwest quarter of the southwest quarter of section 19 (21 N., 8 E.) in the lower terrace and flood plain of a branch to Pipe Creek, telegraph poles and cellars are said to be in the gravel. The main part of the gravel is beneath the ground-water level.

A bed of gravel and fine sand merging frequently into one another underlies several acres in the northwest quarter of section 31 (21 N., 8 E.) on the J. Bronnenberg place. This bed rests upon a clay bottom, is below ground-water level, has a stripping ranging between 2 and 4 feet and a thickness of 10 feet. The sizes of the material are considerably below the average.

In the central part of section 18 (21 N., 8 E.), on the lots of Mrs. D. M. Scott, is a bed of gravel and fine sand in the terrace to a branch of Pipe Creek. It underlies about 5 or 6 acres, has a depth of 4 feet and a stripping of 2 1/2 feet. The sizes of the

material are average and the amount of weathering high, the colors being yellow and brown.

Along another branch of Pipe Creek on the W. M. King farm, in the southwest quarter of section 29 (21 N., 8 E.), a bed of gravel and fine sand beneath ground-water level has been found to underlie 2 or 3 acres in the flood plain; but as to depth, nothing is known.

A ditch dug across the farms of U. C. Vermillion, S. A. Vermillion and E. R. Dilts, in the southeast quarter of section 33 and the southwest quarter of section 34 (21 N., 8 E.), showed gravel, more or less, all along in its bottom. This area would be an especially good one for testing for the setting of a gravel excavator or some other machine, since there is a great scarcity of road material in this vicinity.

Beneath ground-water level and in the flood plain of a branch of Pipe Creek deposits are found on the farms of P. Hartman, in the northeast quarter of section 8; J. B. Schreiber, in the northwest quarter of section 9; R. H. Zimmerman, in the northeast quarter of section 9, and D. Webster, in the southeast quarter of section 4 (21 N., 8 E.). An examination of that on the Webster place showed from 2 to 5 feet of stripping and a depth of 18 feet without any bottom being found. The extent has not been well determined, but another location for dipping is said to be known. The rock percentages are about average and the sizes of the material are a little above, there being 13 per cent. of clay and 24 per cent. of gravel. These sizes, together with the unoxidized condition, makes this a particularly good road metal. The deposits on the other farms are only known to be present, depths and extents not being known.

Township 20 North, Range 20 and Parts of 6 and 8 East.

A gravel, which contains much sand, is found on the B. W. Scott property in the southwest quarter of section 26 (20 N., 8 E.). The extent of the bed is 2 acres, depth 11 feet and stripping from 1 to 3 feet. The material is only suitable for very light repair work.

In the east-central part of section 22 (20 N., 8 E.), on the land of I. W. Burton, is a large deposit of fine medium sand to coarse

sand mixed with a fine sand. Roads repaired with this material are sandy and not durable.

In a morainic ridge which runs southeast and southwest from the V. J. Pence place in the southeast quarter of section 2 across the N. Fountain, L. Childs, and George Heagy farms of section 11, and across the W. W. Hancock, of section 14, and onto the J. Noland and L. Noland property of the southeast quarter of section 15 (20 N., 8 E.), are some large deposits of gravel.

On the Noland place the gravel extends for 100 yards north of the pit to where a dug well shows a depth of 25 feet. At a number of places in the ridge on this farm gravel is known to be present. At the pit the depth is 14 feet and stripping 1 foot. The sizes of the material are 12 per cent. clay, 10 per cent. fine medium sand, 5 per cent. medium sand, 15 per cent. coarse sand, 35 per cent. roofing pebble, 22 per cent. gravel, and 1 per cent. boulder. The amount of oxidation is about the average.

By dug well records, post holes, and plowing, Mr. Heagy has found on his farm the area underlain with gravel and sand to range from 70 to 200 yards in width and to be 500 yards long. At his pit the depth of the deposit is 20 feet and the stripping from 1 to 3 feet. The mean of two samples gives the following sizes of the material: Eight per cent. clay, 12 per cent. fine medium sand, 12 per cent. medium sand, 11 per cent. coarse sand, 22 per cent. roofing pebble, and 35 per cent. gravel. About 1,100 cubic yards of this material are used in the annual building and repairing of roads.

Workable deposits, with similar material, are reported on the Pence and Childs places. Without doubt a hundred thousand cubic yards of gravel might be obtained from this ridge.

In the bluff of Kilbuck Creek, in the southeast quarter of section 10 (20 N., 8 E.), on the William Fountain farm, several acres are known to be underlain with gravel and fine sand, merging into one another. The stripping is from 1 to 4 feet and the depth over 10 feet. The quality is similar to that on the J. and L. Noland farm.

Along a branch of Kilbuck Creek, on the Jacob Maynard farm in the southeast quarter of section 5 and the L. Johnson in the southeast quarter of section 7 (20 N., 8 E.), gravel has been found to underlie the surface, but extent and depth are not known.

A deposit of gravel, fine sand and clay are found with all kinds of gradations between them beneath from 2 to 8 feet of surface in the southeast quarter of section 19 (20 N., 8 E.), on the land of John Tappen. The depth is 18 feet at the pit. Although 8 or 9 acres are underlain, it is very questionable as to the workability, on account of fine sand and clay. Something like 3,000 cubic yards are used in building and repairing the roads for 5 miles north, 4 miles west, and 3 miles east.

In the bluff of Kilbuck on the property belonging to H. Cawaday in the southwest quarter of section 31 (20 N., 8 E.), is a bed of gravel 12 feet thick and underlying from 1 to 4 feet of soil at the pit. Four hundred yards north of the pit is another opening in the bluff, which shows a similar material. This indicates a possible connection and a large amount of gravel. The sizes of the material are below the average and the oxidation a little higher.

Mingled with considerable sand and clay is a gravel deposit in the southwest quarter of section 31 (20 N., 8 E.), on the place of A. Forkner. At the pit the stripping is from 3 to 6 feet and the depth from 7 to 15 feet. The area underlain is 2 or 3 acres, but the sand and clay are so great that the deposit can hardly be termed workable.

There are no gravel deposits that are being used in range 7 of this township, and only two locations that are at all promising. One of these was found in digging a ditch on the H. Cawaday and J. Cawaday farm in the southwest quarter of section 15 (20 N., 7 E.). Besides finding a few inches of gravel in the bottom of the ditch, no tests were made as to depth or extent. Another was found in drilling a well on the property of T. F. Lee in the northeast quarter of section 15 (20 N., 7 E.). The drillers claimed a depth of 40 feet of gravel, but the comminuted condition in which the material was bailed out made it almost impossible to tell much about the quality.

On the bluff of Pipe Creek, underlying 2 or 3 acres, is a bed of gravel, fine sand and clay merging into one another, in the southwest quarter of section 1 (20 N., 6 E.), on the land belonging to J. W. Benefield. The thickness is 7 feet and the stripping 2½ feet. The rock composition and size of the material are average, and the amount of weathering a little above. A similar deposit

is found on the S. Lister place in the southeast quarter of section 2 (20 N., 6 E.). The extent is not determined.

Along a small tributary to Pipe Creek in the northeast quarter of section 14 (20 N., 6 E.), on the farm of Noah Richwine, is a workable bed of a small-sized gravel underlying about 5,000 square yards, as very general tests with a post auger have shown. The stripping is 3 feet and the depth undetermined. A still smaller material is found on the Z. Beckwith place in the northeast quarter of section 20. It is too fine for anything other than very light local repair work.

A workable deposit in the bluff of White River is located on the farms of I. E. McClintock in the southeast quarter of section 35, and of M. J. Wise in the southwest quarter of section 36 (20 N., 6 E.). At the pits the depth is 15 feet and stripping 1½ feet. The rock composition is about average, the sizes of the material a little below, oxidation somewhat higher, and durability slightly lower. On various farms along White River gravel is known to underlie the terraces and bluffs, but careful tests have not been made to learn the depth or extent. Several small pits have been opened, and among these is one on the John Wise property, in the southeast quarter of section 33 (20 N., 6 E.), where gravel of an average quality is obtained.

Township 19 North, Range 7, and Parts of 6 and 8 East.

An ex-trustee of the civil township of Stoney Creek says that 10 acres, in the flood plain of a small creek, on the places of S. Wright and L. Aldred in the southeast quarter of section 21 (19 N., 6 E.), have been carefully tested and are known to be underlain with about 10 feet of gravel, which is beneath the ground-water level and is covered with 2½ feet of stripping. For sizes of the material, 10 per cent. is clay, 15 per cent. fine medium sand, 15 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 19 per cent. gravel, and 1 per cent. boulder; and the rock composition is about the average. This material is pumped out with a gravel pump and is used in building and repairing the roads for several miles about. These roads are, in general, smooth and durable.

An average sized material is found on the farms of Susan Wise in the northeast quarter of section 3 (19 N., 6 E.), and D. W. Kemp in the southeast quarter of section 1 (19 N., 6 E.). The quantity of either deposit is probably workable. On the N. Ryan place in the southeast quarter of section 1 (19 N., 6 E.), is a deposit beneath from 2 to 5 feet of stripping, and with a depth of 12 feet. The extent is not known. The size of the material and rock composition are about the average.

Five feet of gravel underlying, with from 2 to 5 feet of stripping, a surface of several acres is found in the southwest quarter of section 5 (19 N., 7 E.). The bottom of the bed is clay. Very noticeable changes from gravel to fine sand are often met with. The sizes of the material and rock percentages are about the average. Heavy stripping and a shallow bed makes this deposit rather inavailable.

On the property of R. W. Wilson in the northeast quarter of section 9 (19 N., 7 E.), is an exposure of gravel and fine sand showing, more or less, for 400 yards in the bluffs of White River. Probably one-half of the material is fine sand and one-half gravel. The depth at the pits is about 14 feet and the stripping from 2 to 7 feet. The color of the material is brown and red, the rock composition about average, and the size of the material a little above. On the road this material packs well and is durable.

A workable amount of gravel is found on the J. W. Sansberry land in the southwest quarter of section 10 (19 N., 7 E.), but it is so commingled with sand and clay that, for the present, it is not a practicable deposit.

In the bluff of White River, under from 2 to 5 feet of stripping and resting on a clay bottom, is a bed of gravel underlying about 4,000 square yards in the northeast quarter of section 10 (19 N., 7 E.), on the J. H. Hatter property. The rock composition is about average, but the sizes of the material are far below the average, and the amount of weathering is high. These characteristics, together with the frequent gradations into fine sand and clay, make the deposit rather undesirable.

Another bluff deposit is found in the northwest corner of section 12 (19 N., 7 E.), just north of the bridge. A cross section of 450 square yards is seen in the pit, which shows a stripping rang-

ing between 3 and 6 feet and a depth of 15 feet. The quality is a little above the average, for a deposit above ground-water level, the sizes of the material being somewhat above the average and the oxidation less. This material is used in the repair and building of roads for as far as 6 miles north.

In a morainic ridge running almost north and south through section 35 and into the southern part of section 26 (19 N., 7 E.), are at least several hundred thousand cubic yards of available gravel. A number of openings have been made in this ridge, among which are those on the Thomas McCollough property in both the northwest and southwest quarter of section 35, on the S. Orbaugh place in the southwestern part of the same section, and the H. Seybert in the northwestern, The Big Four Ry. Co.'s pit is in the south central portion of section 26 (19 N., 7 E.). All of these deposits are largely unstratified, being made up of a heterogeneous mass of gravel, clay and fine sand. Because of this careful investigating should be done before opening up a pit. The stripping ranges from 1 to 10 feet, and the depth from 8 to 25 feet. The gravel, excluding fine sand, is, in general, about the average for size.

Another morainic bed is found on the property of W. Harmeson in the northeast quarter of section 25 (19 N., 7 E.). It, also, is a commingled mass of gravel, fine sand and clay. This bed has a clay bottom, a depth of 7 feet, a stripping of from 2 to 3 feet, and the sizes of the material are about the average. The amount of material is not determined.

In the northwest corner of section 6 (19 N., 8 E.), on the land belonging to R. McFarland, is a large workable deposit in the stream bluff. This deposit continues on north across the road and onto the next farm, following the bluff 150 yards. It also follows the bluff south for some distance. The depth is 15 feet and the stripping from 2 to 6 feet. Excluding large masses of fine sand and hardpan, the sizes of the material are a little above the average.

Along a stream on the G. A. Sims land in the northeast quarter of section 2 (19 N., 8 E.), are several workable beds of gravel. A pit, in one of these, shows a thickness of 10 feet, and a stripping ranging between 1 and 3 feet. The rock percentages and dura-

bility are about the average and the sizes of the material are a little above.

Two or 3 acres, in the northwest quarter of section 11 (19 N., 8 E.), on the W. B. Bronnenberg place, are underlain by a deposit of gravel and fine sand, which very frequently grade abruptly into one another. The stripping is from 1 to 4 feet, and the depth, at the pit, is 25 feet. The rock composition is about the average, and the sizes of the material are 7 per cent. clay, or fine conglomerate, 12 per cent. fine medium sand, 10 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 29 per cent. gravel and 2 per cent. boulder. The clay is made up of minute particles of gravel with an almost pure calcium carbonate matrix, which makes the best cement that is found in gravel. This cement causes the gravel to pack very quickly, thus forming a hard and smooth road, and one on which the gravel is not working off at the sides.

From the bluffs and terraces of the White River on south for several miles numerous gravel beds, above ground-water level, are known to exist, and road material is hauled only short distances. Openings in some of these deposits have been made on the places of Martin Bryant in the north central part of section 23, of Amos Hodson in the east central part of section 34, of Gray and Williamson in the south central part of section 9, of Samuel Hughel in the central part of section 17, and of a Mr. Beckman in the south central part of section 7 (19 N., 8 E.). With a large portion of this gravel the greatest difficulty is the fineness, and consequently high amount of weathering. A coarse gravel will stand the heavier traffic far better than the fine.

Under from 1 to 5 feet of stripping, and with a depth of 30 feet, at the pit, is a bed of one-third gravel and two-thirds clay and fine sand on the M. Tousey lots in the south central part of section 7 (19 N., 8 E.). The amount of surface underlain is about 2 acres, as is seen from various diggings; but the size being considerably below the average and there being so much fine sand and clay to contend with, the deposit could not well be operated, if it was not for supplying considerable sand for concrete work at Anderson.

On the land belonging to Mrs. J. H. Stanley in the southeast

quarter of section 18 (19 N., 8 E.), is a bed of gravel underlying several acres, with a stripping of from 2 to 4 feet, and a depth of 11 feet. The rock composition is average, and the sizes of the material are above. About 1,000 cubic yards are used in the annual repair and building of the roads, which are smooth, hard and durable. Other workable deposits with an average size material are found in the bluff of White River on the S. Allen farm in the southeast quarter of section 17, and the Bronnenberg land in the southwest quarter of section 6 (19 N., 8 E.).

Along the bluffs of a small stream, on the W. A. Forkner property in the southwest quarter of section 23, and that of E. Gustin in the northeast quarter of section 26 (19 N., 8 E.), are gravel and fine sand beds, which, as has been learned by crude tests, underlie 5 or 6 acres. At the pits the stripping is from 1 to 3 feet, the depth about 12 feet, and the sizes of the material and rock composition about average, if the fine sand and clay, into which the gravel often merges, be excepted. Another deposit is known to exist on the land belonging to E. R. Williams, in the east central part of section 34 (18 N., 8 E.). Depth and extent are not known.

Township 18 and Part of 17 North, Range 7 and Parts of 6 and 8 East.

Abundance of gravel is found in the bluffs of Fall Creek. Pits have been opened in Township 18 North, Range 8 East, in the bluffs on the farms of H. Cummins in the northwest quarter of section 2, D. Keesling in the southeast quarter of section 3, E. Hodson in the northwest quarter of section 11, J. Rent and J. Franklin in the northwest quarter of section 15, J. Rector of the northeast quarter of section 16, and Z. Mustard in the north central part of section 18.

The Cummins deposit is workable, has a depth of 14 feet, and from 2 to 6 feet of stripping. The sizes of the material and rock percentages are about the average.

The Keesling deposit is workable and is made up of a very splendid quality of material. The sizes of the material are 9 per cent. clay, 10 per cent. fine medium sand, 5 per cent. medium sand, 10 per cent. coarse sand, 20 per cent. roofing pebble, 45 per cent. gravel, and 1 per cent. boulder. The depth of the de-

posit is 11 feet, and the stripping from 1 to 2 feet. On the Rector place the deposit is workable and the material is about the average in size, rock composition and amount of weathering. The bed is 14 feet deep without a bottom being found, and has a stripping ranging between 1 and 2 feet. The Mustard deposit has from 2 to 4 feet of stripping, a depth of 10 feet, and is probably workable. The rock composition is about the county average, and the size of the material is considerably above.

A very fine material is found on the place of J. Biddle, in a ridge in the northwest quarter of section 18 (18 N., 8 E.), and N. Cox in the northeast quarter of section 13 (18 N., 7 E.). Gradations into fine sand and clay are frequent. The areas underlain, as shown by post auger holes and various excavations, comprise about 6 acres. The stripping, at the pits, is 2 feet and the depths 11 feet.

In the bluff of Lick Creek in the northwest quarter of section 28 (18 N., 8 E.), on the land of S. Walker, is a deposit underlain, as crude tests have indicated, about 5,000 square yards. The stripping is from 2 to 6 feet, and depth not determined. The gravel is of a very good quality for road building, the size being above the average and the oxidation lower. The rock composition is average. The stripping is from 1 to 3 feet.

Gravel on an average quality is reported on the F. M. Williams farm in the northwest quarter of section 32 (18 N., 8 E.), on the R. M. Lewis place in the southeast quarter of section 5 (17 N., 8 E.), and on that of M. Compton in the southwest quarter of section 4 (17 N., 8 E.). Extents, depths and amounts are not known.

A workable deposit containing a high percentage of clay and fine sand is found in the bluff of Fall Creek on the farms of W. M. Hull and M. E. Cox in the southeast quarter of section 12 (18 N., 7 E.). The stripping ranges from 2 to 10 feet, and the material is about average in size.

Just south of the bluffs of White River 300 or 400 yards, along a small tributary, is the large pit of the Union Traction Co. A wall of this pit presents a cross section 200 yards long and 5 yards wide. The section is as follows: (1) Stripping, 2½ feet; (2) average size gravel, 4 feet; (3) boulders and fine sand, 1 foot; average size gravel, 2½ feet; (4) gray gravel grading

from a fine to an average size material, 7½ feet. Fully 95 per cent. of this section is gravel and about 5 per cent. fine sand. This deposit is known, by tests, to extend back from the pit wall for 200 yards. About 300 cubic yards are taken from this pit daily, and used for ballast on the interurban line. As a road material this deposit is about the average for the county.

Another deposit, one-fourth mile west of the Union Traction pit, is in the bluffs of White River on the C. McCarty and F. McCarty place. It is similar to the Union Traction deposit in quality, has a stripping of ½ to 2 feet, and a depth of 30 feet. A section of 100 by 6 yards is exposed at this pit, and it seems very probable that there may be a connection between this and the Union Traction deposit. If so, there is an area of 450 by 350 yards with a depth ranging between 18 and 30 feet.

Considerable gravel is reported in the terraces on the Henry Coburn property, which is across Fall Creek from that of the Union Traction Co. In the bluffs of Lick Creek deposits are found on the farms of R. A. Kirkman in the northeast quarter of section 4, B. Davis in the northeast quarter of section 5, and U. McCartney in the southeast quarter of section 4 (17 N., 7 E.). On the Kirkman place the bed is 9 feet deep, and is under 2 feet of surface. The material is about the average for size and rock composition.

Located in a ridge, which extends about north 10 degrees east, in the northeast quarter of section 33, southeast quarter of section 28, and southwest quarter of section 27 (18 N., 7 E.), and is from 70 to 200 yards wide, are several good locations for gravel pits above ground-water level. Pits that have been opened in this ridge are those of the P. Loy and L. Kinnard farms. The former pit shows 15 feet of gravel and no bottom, from 1½ to 2½ feet of stripping, and an average size material and rock composition. About 800 cubic yards, at a cost of 15 cents each, are used in the annual repair and building of the roads for 1½ miles west, 1½ miles north, 1 mile east, and ½ mile south. The latter pit shows a depth of 10 feet, and a similar size, rock composition and stripping. Other openings have also been made in this ridge, which indicate that a very large quantity of material might be obtained in this vicinity.

In a small morainic ridge on the place of B. F. Aimen in the

south central part of section 15 (18 N., 7 E.), is a bed of gravel underlying 2 feet of surface and with a depth of 12 feet. The sizes of the material, excluding fine sand and clay masses, is a little below the average. The amount of gravel, in this particular ridge, is not sufficient to be termed workable, but if a number of other similar ridges, which are in the immediate neighborhood, and are known to contain some gravel, are considered, 10,000 cubic yards can easily be obtained.

In some small ridges in the southwest quarter of section 10 on the B. F. Aimen land, and on that of E. A. Dille in the southwest quarter of section 10 (18 N., 7 E.), are some gravel beds, with depths of 8 feet, strippings ranging from 1 to 4 feet, and extents undetermined. The quality of the gravel for good road building and repairing is about the average for the county.

In the southern part of the glacial ridge, which was described in connection with the Big Four Ry. Co.'s pit, is a large gravel bed on the E. W. Gilbert land, in the northwest quarter of section 2 (18 N., 7 E.). The thickness of this bed is 15 feet, at the pit, and the stripping from 1 to 8 feet. The mean of two samples gives the following sizes of the material: 5 per cent. clay, 7 per cent. fine medium sand, 15 per cent.; medium sand, 28 per cent. coarse sand, 30 per cent. roofing pebble, 13 per cent. gravel, and 2 per cent. boulder. The rock percentages are about the average.

On the places belonging to G. A. Williamson and C. Goodrich in the northeast quarter of the southeast quarter of section 13 (18 N., 6 E.), several acres in the flood plain of a tributary to Fall Creek are known by tests to be underlain by gravel. These tests have been dug wells, post auger holes and an old bank pit, which was worked down to water level and then abandoned.

In the bluff of this same stream in the east central part of section 25 (18 N., 6 E.), on the property of J. R. Page, is a workable bed, which is beneath 3 feet of surface and has a depth of 12 feet, at the pit. The rock composition is about average, and the sizes of the material are a little above. Roads on which it is used are smooth and durable, where proper care is given them.

In the bluff of Fall Creek and on the farm of John Raymer in the northwest quarter of section 34 (18 N., 6 E.), is a rather extensive gravel and sand deposit. On this place there are three gravel pits, the two ends being 300 yards apart. The extent back

from the face of the bluff is known to be at least 10 or 11 yards. At the pits there is from ½ to 3 feet of stripping, and a depth of from 8 to 12 feet. The sizes of the material are 9 per cent. clay, 14 per cent. fine medium sand, 15 per cent. medium sand, 20 per cent. coarse sand, 22 per cent. roofing pebble, and 20 per cent. gravel. About 600 cubic yards of this material, at from 10 to 12½ cents each, are used in the annual building and repairing of the roads for 4 miles north. It is said to give very good satisfaction.

In the northwest quarter of the southwest quarter of section 34 (18 N., 6 E.), on the property of E. F. Springer, is a bed of three-quarters sand and one-quarter gravel, underlying about 10 acres in the bluff of Fall Creek. The depth is 15 feet, stripping 4 feet, and the size, excluding fine sand, is somewhat below the average. This deposit is not worked, at present, on account of sand.

Another deposit on a farm belonging to E. F. Springer is found in the southwest quarter of the southwest quarter of section 34 (18 N., 6 E.), on the bluff of Lick Creek. Here is a bed underlying 2 or 3 acres with a depth at the pit of from 7 to 15 feet, and an average stripping of 4 feet. The sizes of the material are about the average, and the fine sand is not abundant. The flood plain and terraces of Lick Creek have at this point a width of one-quarter mile. Both are said to be underlain by gravel at a number of places, but neither have been opened because of the more available bluff deposits.

A gravel of average quality is reported in the bluffs of Fall Creek in the southwest quarter of section 33 (18 N., 6 E.), on the places of M. Wiggins, T. Wiggins and N. Vanzandt.

Without doubt many more deposits will be found in the bluffs, terraces and flood plains of Fall and Lick Creeks when the demand requires them; but for sections 1, 2, 3, 4, 9, 10, 11, 12, 14, 15, and 16 (18 N., 6 E.), the need is very different, gravel being hauled from 3 to 5 miles to repair and build the roads of this vicinity. The writer would advise that careful investigations be made as to the durability and satisfaction given by the crushed limestone of the Miller quarry, 1½ miles northeast of Ingalls. Because of its greater durability, it will probably be the cheaper road material.

LIMESTONE.

The general location and ages of the limestone beds have been discussed in the introduction.

One and one-half miles northeast of Ingalls in the northwest quarter of the northeast quarter of section 36 (18 N., 6 E.), on the property of David V. Miller, are 60 acres underlain by limestone, which is available, as tests by Mr. Miller have indicated. A section of the stone taken from the quarry is as follows:

Section at the Miller Quarry.

	Feet.
1. Thin bedded, light buff limestone	4
2. A gray limestone, with beds ranging between 1 and 3½ feet in thickness	7

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of Niagara Limestone from the Miller Quarry.**

Specific gravity	2.7	French coefficient of wear	7.2
Weight per cu. ft. (lbs.)	168.4	Hardness	8
Water absorbed per cu. ft. (lbs.)	.29	Toughness	5
Per cent. of wear	5.6	Cementing value—Dry	16
		Wet	50

"Fair resistance to wear and fairly good cementing value. Suited for highway and country-road traffic."—Page.

A chemical analysis by the chemist at the Road Testing Laboratory shows the composition of the limestone to be as follows:

Chemical Analysis of Niagara Limestone from the Miller Quarry.

	Per cent.
Alumina (Al_2O_3)	.60
Iron oxide (Fe_2O_3)	....
Lime (CaO)	50.00
Phosphoric acid (P_2O_5)	.17
Insoluble in hydrochloric acid	10.24
Loss on ignition	38.33
Total	99.84

"Insoluble portion is fine sand and silt."

At present D. V. Miller is building a macadam plant, which will crush 150 cubic yards per day.

*For standard of comparison see p. 79.

On the farm of Daniel Abbott in the northwest corner of section 33 (21 N., 7 E.), are about 5 acres underlain with limestone within from 6 to 7 feet of the surface, as has been learned through tests made by Daniel Abbott. At the quarry belonging to Daniel Abbott the following section is exposed:

Section at the Abbott Quarry.

		Feet.
1.	Thin bedded, buff colored limestone	3
2.	A light buff limestone, with beds ranging from 6 to 20 inches in thickness	3

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of Niagara Limestone from the Abbott Quarry.**

Specific gravity	2.7	French coefficient of wear	9.2
Weight per cu. ft. (lbs.)	165.3	Hardness	7.8
Water absorbed per cu. ft. (lbs.)	1.57	Toughness	7
Per cent. of wear	4.4	Cementing value—Dry	28
		Wet	29

"Above the average in resistance to wear, and fair cementing value. Suited for highway and country-road traffic."—Page.

A chemical analysis by the chemist at the Road Testing Laboratory shows the composition of the limestone to be as follows:

Chemical Analysis of Niagara Limestone from the Abbott Quarry.

	Per cent.
Alumina (Al_2O_3)	2.00
Iron oxid (Fe_2O_3)	.76
Lime (CaO)	35.85
Magnesia (MgO)	3.64
Phosphoric acid (P_2O_5)	.10
Insoluble in hydrochloric acid	23.28
Loss on ignition	34.66
Total	100.29

"The insoluble portion consists of fine silt and clay."

In the western part of Alexandria is located the macadam plant of L. C. Nicoson. At the quarry, which is 100 feet from the plant, the following section is exposed:

*For standard of comparison see p. 79.

Section at the Nicoson Quarry.

		Feet.
1.	Stripping	5
2.	Fragmental, thin bedded, buff limestone	5
3.	Light buff limestone, with beds from 2 to 6 inches in thickness	5
4.	Gray limestone, with beds from 6 inches to 3 feet in thickness	15

No. 4 is much superior to No. 2 or No. 3, being harder and less brittle. The extent of the area underlain with available limestone is at least 14 or 15 acres, and probably much greater. About 125 cubic yards are crushed at the plant daily, and are shipped for the most part to other counties, very little being used in the local road building, outside of Alexandria.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of Niagara Limestone from the Nicoson Quarry.**

Specific gravity	2.7	French coefficient of wear	9.3
Weight per cu. ft. (lbs.)	165.3	Hardness	1.8
Water absorbed per cu. ft. (lbs.)	1.41	Toughness	7
Per cent. of wear	4.3	Cementing value—Dry	26
		Wet	28

"Above the average in resistance to wear, and fair cementing value. Suited for highway and country-road traffic."—Page.

A chemical analysis by the chemist at the Road Testing Laboratory shows the composition of the limestone to be as follows:

Chemical Analysis of Niagara Limestone from the Nicoson Quarry.

	Per cent.
Alumina (Al_2O_3)	1.00
Iron oxid (Fe_2O_3)	.75
Lime (CaO)	38.50
Magnesia (MgO)	3.64
Phosphoric acid (P_2O_5)	Trace
Insoluble in hydrochloric acid	21.33
Loss on ignition	34.69
Total	99.91

"The insoluble portion consists of fine silt and clay."

*For standard of comparison see p. 79.

HANCOCK COUNTY.

Area in square miles	290
Population in 1900	19,189
Miles of public roads	605
Miles of improved roads	402
Percentage of roads improved	66.3
Miles improved with gravel	402
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$900
Total original cost of improved roads	$361,800
Annual cost of repairs per mile on gravel roads 5 years old	$60
Miles of improved roads (gravel) built in 1905	7¼
First improved roads built	1860
Proportion of improved roads built since 1895 (per cent.)	30
Satisfaction of farmers with investment in improved roads	Good
Authority	Wm. I. Garriott, County Auditor

HANCOCK COUNTY

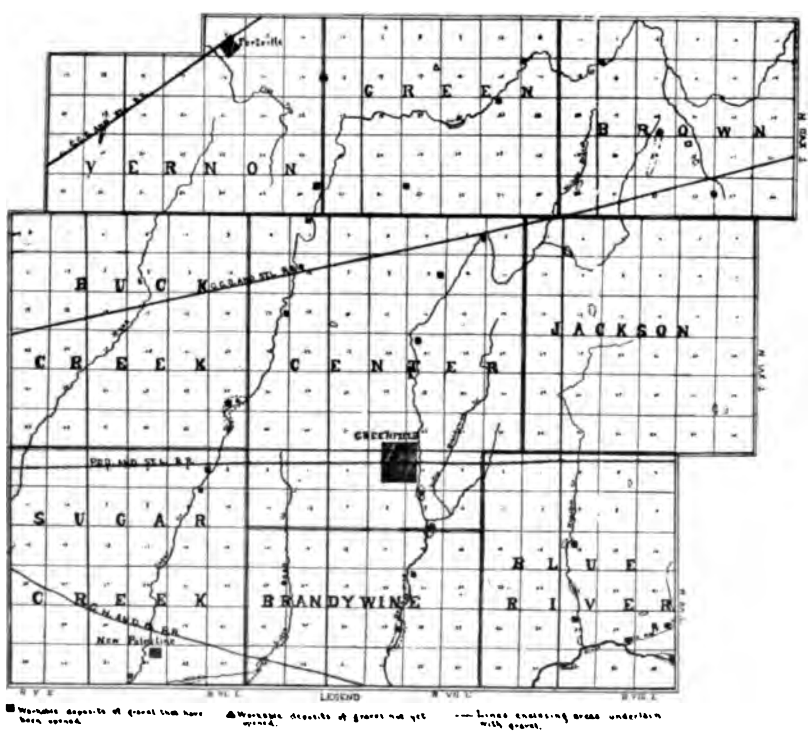

Fig. 37. Illustrating the distribution of road materials in Hancock County.

Hancock County is situated in the east central part of the State, south of Madison and Hamilton, west of Henry and Rush, north of Rush and Shelby and east of Marion Counties. The northern portion is almost a level plain, but the southern is undulatory, having numerous swells of 20 or 30 feet in height. The drainage lines have a southwestern direction.

The gravel deposits of economic importance are found, mainly, in the terraces and bluffs of Sugar, Brandywine, Six Mile and Nameless Creeks, and Blue River. Smaller deposits are found along the smaller streams and in kames, north and south of Eden, and south of Warrington.

In amount and quality of gravel for road building purposes, this county is about the average for central Indiana. The average sizes of material for the county are 4.5 per cent. clay, 11 per cent. fine medium sand, 14 per cent. medium sand, 24 per cent. coarse sand, 30 per cent. roofing pebble, 14 per cent. gravel and 2.5 per cent. boulder, and the rock percentages are 84.5 limestone, 9 crystallines, 3 shale, 1.5 slate, 1.5 chert and .5 sandstone.

The railroad facilities are most excellent. The Peoria Division of the Big Four traverses the northern half of the county from east to west, the Michigan Division cuts the northwest corner, and another division the northeast corner. The P., C., C. & St. L. crosses the southern half from east to west, and the Cincinnati, Hamilton and Indianapolis the southwestern corner. An interurban traction line crosses the county from west to east through Greenfield.

Township 17 North, Ranges 6 and 7, and Parts of 5 and 8 East.

This township of 91 square miles occupies the northern portion of the county, and corresponds to the civil townships of Vernon, Green and Brown. Its principal gravel deposits are located along Sugar Creek, in morainic hills north and south of Eden and morainic ridges south of Warrington.

The percentage of improved roads in Vernon township is 70; in Green, 85; and Brown, 85.

Near the east central part of section 14 (17 N., 6 E.), on the O. Jackson place and in the west central part of section 13 (17 N., 6 E.), on the property of J. Rash, is a morainic hill of 4 or

5 acres, underlain by a bed of gravel, clay and fine sand, merging into one another. The depth ranges from 4 to 20 feet and the stripping from 1 to 9 feet. The sizes of the material are a little below the average, and the rock percentages are 78 limestone, 9 crystallines, 3 chert, 4 shale, 4 slate and 2 sandstone.

Large deposits of gravel are known to exist in the flood plains, terraces and bluffs of Sugar Creek, but those in the bluffs, because of their accessibility, have been the only ones opened. Among the main openings are those on the farms of O. Schneider in the northeast corner of section 35 (17 N., 6 E.), Mr. Wilson in the southeast corner of section 20, H. Hunt in the southwest quarter of section 21, M. Murfin in the north central part of section 22, H. Kelley in the northwest corner of section 14, Hayes heirs in the northeast quarter of section 13 (17 N., 7 E.), and Keller in the northwest corner of section 18 (17 N., 8 E.).

On the Schneider farm a very fine gravel, mingled more or less with fine sand, underlies an area of 150 by 200 yards, as learned by three pits, a dug well and other tests. The thickness of the bed is from 12 to 20 feet and the stripping from 1 to 4 feet. The rock percentages are 70 limestone, 16 crystallines, 4 shale, 4 slate, 4 chert and 2 sandstone. This material, because of its fineness and oxidation, should only be used in the immediate vicinity, unless screening is resorted to.

The workable deposits on the Hunt and Wilson places are also fine and considerably oxidized. By screening, a much less oxidized and better quality of material can be obtained.

Pits and groundhog diggings signify that an area of 100 by 100 yards are underlain by gravel on the M. Murfin property. This deposit rests upon a clay bottom, has a depth ranging between 10 and 20 feet and a stripping between 2 and 4 feet. An average of two samples gives the following sizes of material: 5 per cent. clay, 11 per cent. fine medium sand, 11 per cent. medium sand, 21 per cent. coarse sand, 37 per cent. roofing pebble, 14 per cent. gravel and 1 per cent. boulder. This material is used in the repairing and building of roads for 1 mile west, 1 mile north, ½ mile east and 3 miles south. These roads, where properly cared for, are smooth, durable and giving good satisfaction.

Both the Keller and Hayes deposits contain a material which

frequently grades into fine sand, is about the average in rock composition and is somewhat below in size. Both pits have been worked down to ground-water level and no bottom has been reached. The stripping ranges between 2 and 5 feet. The former, as learned in digging two wells and post auger borings, underlies about 2 acres, and its depth, at the pit, is from 7 to 15 feet. The depth of the second deposit is from 6 to 10 feet, and the extent is unknown.

In a kame on the farm of Mrs. D. Fort in the northeast quarter of section 32 (17 N., 7 E.), is a bed of gravel, which has been a source of supply for road material during the past 35 years. Two acres have been worked to ground-water level and no bottom found, and 1 acre still remains to be opened. The depth of the bed is from 6 to 15 feet to water level, and the stripping is 2 feet. Both in size and rock composition, the material is about the average for the county. About 800 cubic yards, at a cost of 15 cents each, are used in the annual building and repairing of the roads. Its size causes it to be less weathered and more durable than that in the bluffs of Sugar Creek. The fact that no bottom has been found will make this a very favorable place to make tests for dipping or chaining when the demand requires such.

Underlying an area of 20 acres, as has been shown by various tests, is a bed of gravel on the place of William Jones in the northeast quarter of section 17 (17 N., 7 E.). This bed has been worked to the water level and no bottom has been found. The stripping is from 2 to 4 feet, the depth 12 feet, the size of material above the average, and the rock percentages 74 limestone, 12 crystallines, 6 shale, 3 slate, 2 chert and 3 sandstone. About 600 cubic yards, at 15 cents each, are used for 3 miles west, 1 mile north, ½ mile east and 1 mile south, in the annual repairing and building of the roads, which are smooth, durable and giving good satisfaction, where properly attended to.

Near the central part of section 36 (17 N., 7 E.), on the land belonging to J. Braddock, a gravel bed is found in a stream bluff. The area underlain, judging by the space intervening between two pits, is 35 by 150 yards, the thickness is from 3 to 10 feet, and the stripping from 2 to 4 feet. The size of the material is

considerable below the average, and large lenses of fine sand are frequent. The rock percentages are 93 limestone, 5 chert, 2 shale, ½ slate and ½ sandstone.

In a broken morainic ridge, extending approximately north and south, are gravel beds, located in the southwest quarter of section 20 on the William Marsh place, and in the southwest quarter of section 29 (17 N., 8 E.), on the J. Price property. Both of these deposits are about average in rock composition, a little below in size of material, have been worked down to ground-water level without any bottom to the gravel being found, and have a stripping ranging between 2 and 5 feet. The former has a depth of 7 to 20 feet, and underlies, as has been learned by post auger borings and the plowing up of gravel, about 2 acres. At the pits frequent gradations into fine sand are quite noticeable. The Marsh material is used on the roads for 4 miles west and 5 miles east. It gives fair satisfaction, but does not wear as well as a coarser and less oxidized material. Very likely, other similar deposits can be found in this same ridge, when tests are made.

A morainic deposit is found, underlying about 2 acres, on the place of R. Titus in the northwest quarter of section 28 (17 N., 8 E.). The depth of the deposit ranges between 6 and 20 feet and the stripping between 2 and 6 feet. An average of three samples gives a material with the following sizes: 4 per cent. clay, 15 per cent. fine medium sand, 20 per cent. medium sand, 35 per cent. coarse sand, 25 per cent. roofing pebble and 1 per cent. gravel. The rock percentages are about the average for the county. Abrupt merging of the gravel into fine sand is common. This material is used on the roads for 5½ miles northeast.

A morainic deposit of about 2 acres, as shown by the exposures in two pits, a dug well which shows 20 feet of gravel, and other tests, is found on the farms of J. Keck and George Reeves, in the southwest quarter of section 34. The stripping is from 2½ to 7 feet, and the depth, above ground-water level, from 4 to 10 feet. In the bottom of the Keck pit, a pipe was driven down for 10 feet below water level and no bottom found. The rock composition is about the average and the size of the material a little below. Gradations of gravel to fine sand and clay are frequent.

Township 16 North, Ranges 6, 7 and Parts of 5 and 8 East.

In this area of 119 square miles, which occupies the central part of the county, the workable deposits of gravel are, as far as is known, confined to the bluffs, terraces and flood plains of Brandywine and Sugar Creeks.

This congressional township includes the three civil townships, Buck Creek in the west side, Jackson in the east, and Center in the central part. The percentage of improved roads in Buck Creek is 50; in Center, 82; and in Jackson, 75.

No workable deposits of gravel are known in the western part of the civil township of Jackson. However, small deposits are present on the J. Smith property. One of these is in the southwest quarter of section 26 in a flood plain and the other in a bluff in the southeast quarter of section 27 (16 N., 8 E.). The first deposit contains from 5 to 7 feet of stripping, and underlies an area of 2 acres, in which the bank pit has been worked to groundwater level and no bottom to the gravel found. No tests have been made to determine the depth. The second pit has 5 feet of stripping, a depth of 7 feet and a known extent of 35 by 10 yards.

Resting upon a clay bottom and with a stripping of from 1 to 7 feet, is a bed of gravel on the Braddock heirs property in the southwest corner of section 6 (16 N., 8 E.). The depth is from 4 to 10 feet and the area underlain is about 2 acres, as rough tests have indicated. An abrupt grading of the gravel into fine sand is very common. The sizes of the material, excepting fine sand, are above the average. The material has been used for 2 miles north, 2 miles east, 5 miles south and 2 miles west in the building and repairing of roads, which have been very durable. Further operation in this pit will be difficult on account of the fine sand and heavy stripping. At a number of places in the bluffs, terraces and flood plains of Brandywine, gravel is reported to be present, but only in a few of these have pits been opened and tests made that give an idea as to the possible amount of material. Some of these are found on the McIntyre place in the east central part of section 3, on the farms of E. Martin in the central part of section 16, F. Hinchman in the northwest

corner of section 21 and F. Boots in the southwest quarter of section 21 (16 N., 7 E.).

The McIntyre deposit is in the bluff, with 50 to 200 yards known to be underlain by gravel. The bed rests upon a clay bottom, is above ground-water level, has a thickness of from 6 to 15 feet and a stripping ranging between 1 and 3 feet. The mean of two samples gives the average size of material for the county. The rock percentages are 91 limestone, 6 crystallines, 2 shale, ½ chert, ¼ slate and ¼ sandstone. This material will make a durable road.

The deposit in the east bluff of Brandywine, on the Hinchman place, consists in layers of fine sand interstratified with gravel. At the pit the stripping is 2 feet and the depth to the ground-water level is 13 feet. The area underlain by gravel is 70 by 80 yards, as scattered tests have indicated. The rock composition is about average and the size of material is a little below.

The Boots deposit is found in the first terrace above the flood plain, and underlies an area of 100 by 100 yards, as shown by the pit openings and other tests. The depth is 7 feet and the stripping 3 feet. The rock percentages are about the average and the sizes of the material are 7 per cent. clay, 7 per cent. fine medium sand, 3 per cent. medium sand, 8 per cent. coarse sand, 30 per cent. roofing pebble, 40 per cent. gravel and 5 per cent. boulder. This material, for durability, is among the first of those above ground-water level in the county.

Excepting the fine sand, we find a similar gravel, in size and rock composition, on the R. Frost land in the southeast quarter of section 9 (16 N., 7 E.). This bed is located in the bluff of a tributary to Brandywine, possibly underlying an area of 40 by 50 yards, as learned through a few scattered tests, has a depth of 20 feet and a stripping of 2 feet.

A deposit, which is two-thirds fine medium sand and one-third an average size gravel, is found in the southwest quarter of section 18 (16 N., 7 E.), on the land belonging to R. Boyd. It contains 3 feet of stripping and has a depth ranging between 8 and 20 feet. The extent is undetermined.

As in the congressional township 17 North, the bluffs, terraces and flood plains still contain considerable gravel, as learned by

post holes, groundhog diggings and other excavations. Pits have been opened in the bluff on the property of O. Groves in the northeast quarter of section 1, on the J. Jared land in the northwest quarter of section 12, in the first terrace above the flood plain on the J. O'Donnel farm in the northeast quarter of section 14 and on the first terrace above the flood plain on the Mary I. Duncan property in the southeast quarter of section 27 (16 N., 6 E.).

The Groves deposit, underlying an area of 40 by 150 yards, has a depth of from 12 to 20 feet and a stripping of 2 feet. The material frequently grades into fine sand. The mean of two samples gives the following sizes: 4 per cent. clay, 15 per cent. fine medium sand, 25 per cent. medium sand, 34 per cent. coarse sand, 21 per cent. roofing pebble and 1 per cent. boulder. The rock percentages are about the average. This material is too fine to give the best wear.

The Jared deposit contains considerable hardpan, and for this reason the gravel, which underlies about 2 acres and has an average size and rock composition, is rather inavailable.

The O'Donnel is known by two pits and post auger holes to underlie about 8,000 square yards, to have from 1 to 2 feet of stripping, and a depth of 7 feet to water level, without any bottom being found. The sizes of the material and the rock percentages are about the average. Undoubtedly considerable more of this material can be found in this terrace if the tests be extended. The quality is very good, the material being of a fair size, little weathered and there being sufficient clay to make it pack well.

The Duncan pit is the only one in the civil township of Buck Creek. It is known, by tests through plowing, post auger boring and various pits, to underlie, either as gravel or fine sand, an area of 200 by 300 yards. The bottom to the bed has not been found, but at the pit, a depth of 10 feet above water level and 6 feet below are known, and a stripping of 2 feet. An average of three samples gives a material with the following sizes: 6 per cent. clay, 10 per cent. fine medium sand, 12 per cent. medium sand, 18 per cent. coarse sand, 20 per cent. roofing pebble, 23 per cent. gravel and 11 per cent. boulder. This material is of exceptionally good quality. About 4,500 cubic yards are used in the annual repair

of the roads for 7 miles west, 7 miles north, 4 miles east and 1 mile south; and all of these roads, where properly attended to, are smooth, durable and giving good satisfaction.

Immediately south of this farm and in the same terrace, the continuation of this deposit is known to be present on the George Black place. The extent is not known, but the topographical position and relation to that on the Duncan farm indicate a very good deposit, both in quality and extent.

Township 15 North, Ranges 6, 7 and Parts of 5 and 8 East.

This area of 102 square miles comprises the southern third of the county, and corresponds with the civil townships Sugar Creek, Brandywine and Blue River. The principal deposits of gravel are found along Sugar, Brandywine, Six Mile Creek and Blue River.

The percentage of improved road in Sugar Creek Township is 88; in Brandywine, 80; and in Blue River, 80.

The gravel deposits of Sugar Creek Township are confined to the flood plains, terraces and bluffs of Sugar Creek, with exception of the bed of gravel on the land belonging to V. R. Snodgrass in the southeast quarter of section 33 (15 N., 6 E.). To get the extent of this deposit, tests have been made at three points, 100 yards apart, in the stream bed and 60 feet at another place from the stream bed, by driving a pipe down into the gravel for 9 feet. No bottom was found and the stripping ranged from 2 to 4 feet. The rock percentages are 89½ limestone, 10 crystallines, ½ chert, ½ shale, ¼ sandstone, and ¼ slate, and the sizes of the material are considerably below the average. In the bluff of Sugar Creek, on the property of J. Mathews in the southwest quarter of section 3 (15 N., 6 E.), is a workable bed of gravel having a depth of 14 feet and an average size of material.

In the bluff of the same stream in the northeast corner of section 9 (15 N., 6 E.), on the land belonging to R. Black, is a bed of gravel underlying a well tested area of 60 by 80 yards, with a thickness ranging between 10 and 20 feet and a stripping between 1 and 4 feet. The sizes of the material are about average and the rock percentages are 77 limestone, 12 crystallines, 8 shale, 2 chert and 1 slate. About 1,000 cubic yards are used for 3 miles

west, 4 miles south and 3 miles east, in the annual repairing and building of the roads, which are smooth and durable.

A material about the average in rock composition and a little below in size is found above ground-water level on the first terrace above the flood plain of Sugar Creek in the southeast quarter of section 31 and the southwest quarter of section 32 (15 N., 6 E.), on the property of G. Murnan. The bed rests on a clay bottom, has from 1 to 4 feet of stripping and a depth ranging between 6 and 12 feet. The area underlain is known to be about 20 by 200 yards, as learned through several pits and other excavations.

In the flood plain of Little Sugar Creek near the central part of section 35 (15 N., 6 E.) on the land of J. Andis, is a bed of gravel mainly beneath ground-water level underlying, as a number of tests are said to have shown, an area of 20 by 200 yards, which follow the stream. The depth above ground-water level is 4 feet and below 15 feet.

A similar deposit is known to underlie the surface in the southeast corner of section 26 (15 N., 6 E.).

East of Little Sugar Creek no deposits of importance are found until the flood plains, terraces and bluffs of Brandywine Creek are reached. From Greenfield on south the first terrace seems to be almost a continuous bed of gravel and sand. At most places the depth to ground-water level is too small or the stripping too heavy, but when the demand becomes great enough many locations for dipping will undoubtedly be found. The main openings are found on the first terrace in the southwest quarter of section 4, in the northwest quarter of section 9 on the Moorehead place, in the bluff on the farm belonging to William Thomas, in the southeast quarter of section 9 and the northeast quarter of section 16 and on the Drapier farm, which adjoins the Thomas on the south; in the first terrace above the flood plain on the places of L. Jeffrey, William Milburn and John Smith, in the northwest quarter of section 21, and William Milburn, in the southeast quarter of section 29 (15 N., 7 E.).

The deposit in the southwest quarter of section 4 and on the Moorehead place has a depth of 6 feet to ground-water level, while the stripping ranges between 2 and 3 feet. The bottom of one pit, which is in a good quality of gravel, covers an area of

about 10 acres and the area intervening between the two pits is fully 10 acres more, thus leaving a possibility of 20 acres being underlain by gravel. The rock percentages are about the average, the sizes of the material are above and the amount of weathering below. For durability on the roads this is one of the best gravels of the county.

By groundhog diggings the area underlain on the Thomas place appears to be about 80 by 100 yards. At the pit the depth is 18 feet, without the bottom being found, and the stripping 3 feet. In size of material, rock composition and oxidation this gravel is about the average. Four thousand cubic yards are used in the annual repairing and building of the roads for 4 miles east, 2 miles north and 4 miles west. The wearing quality is about the average. The Drapier location is a continuation of this same deposit.

The extents of the deposits, on the Jeffery, Milburn and Smith places are such as to make them workable. The depth of the beds to water level ranges between 4 and 7 feet and the stripping is about 3 feet. The rock percentages are about average and the sizes of the material are above. Since a large portion of this material has been below the ground-water level in recent geological times the amount of weathering is low and the durability considerably above the average. Another deposit with an average rock composition and size of material and durability above the average is the Milburn, of section 29. Here the depth is 4 feet to water level and the stripping 3 feet.

In Blue River Township the main deposits occur in the bluffs and terraces of Nameless and Six Mile creeks and Blue River. In the bluffs of Nameless Creek openings have been made on the farms of J. H. Cox, in the northwest quarter of section 18; W. Rewalls, in the northwest quarter of section 9; R. W. Brooks, in the northwest quarter of section 30, and Marion Moore, in the southwest quarter of section 30 (15 N., 8 E.).

The Cox deposit has been worked down to water level over an area of 25 by 110 yards and no bottom found, and the portion still left above water level is 10 by 110 yards. The depth above water level is 20 feet and the stripping from 4 to 7 feet. The sizes of the material, as taken from the average of three samples,

are 5 per cent. clay, 16 per cent. fine medium sand, 10 per cent. medium sand, 21 per cent. coarse sand, 27 per cent. roofing pebble, 16 per cent. gravel and 5 per cent. boulder; and the rock percentages are 89 limestone, 9 crystallines, 1 chert and 1 slate. About 1,500 cubic yards, at a cost of 20 cents each, are used annually for 5 miles north, 1 mile east, ½ mile south and 3 miles west in the repairing and building of roads, which, where taken care of, give good satisfaction.

A similar quality of gravel is found in the Brooks deposit. This deposit, also, has been worked down to ground-water level over an area of 10 by 110 yards, and no bottom found. Of the portion above ground-water level, an area of 20 by 70 yards has been partially tested and seems to be underlain with gravel. The depth of this latter portion is 20 feet and the stripping from 1 to 8 feet. About 500 cubic yards are used in the annual repair and building of the roads for 1 mile north, 1½ miles west, 1 mile south and 2 miles east.

A deposit which is claimed to be workable is found in the northeast corner of section 28 (15 N., 8 E.) on the A. Luse property. The size of the material is somewhat below the average. In the first terrace above the flood plain is a bed of gravel on the land belonging to E. W. Felt, in the southeast quarter of section 29 (15 N., 8 E.). The thickness is 6 feet to water level and the stripping is from 1 to 2½ feet. The area that has either been worked down to water level and no bottom found or is known to be underlain with gravel is about 2 acres. The rock percentages and sizes of material are about the average, but the amount of weathering is lower. This material will make a good wearing road.

In the north bluff of Six Mile Creek in the southwest quarter of section 28 (15 N., 8 E.), on the Stanley place, is a bed of gravel underlying an area of 5 by 100 yards, with a thickness of 9 feet to water level and a stripping of 2 feet. The size of the material is a little above the average.

A bed having a depth of 10 feet and a stripping of 2 feet with a probable extent of several acres, is located in the bluff of White River on the Charles Winslow property in the northeast quarter of section 33 (15 N., 8 E.). The pit on this place has been

worked down to water level and no bottom found. The sizes of the material, as taken from the average of three samples, are 4 per cent. clay, 10 per cent. fine medium sand, 10 per cent. medium sand, 16 per cent. coarse sand, 32 per cent. roofing pebble, 13 per cent. gravel and 15 per cent. boulder. The rock percentages are 90 limestone, 8 crystallines, ½ slate, ¼ sandstone and ¼ chert. With the sizes, rock percentages and a small amount of weathering, we get a very durable and satisfactory road material.

On the farm of David Benford, in the northeast quarter of section 28 (15 N., 8 E.), is a bed of gravel which by the outcroppings seems to follow the bluff of Six Mile Creek for 300 yards. The depth of the deposit to water level is 12 feet and no bottom found and the stripping is 1½ feet. For sizes of the material, rock percentages and quality, the deposit is similar to the Winslow, which is described in the preceding paragraph.

Some small deposits of gravel are found on the Wright place in the southeast quarter of section 5 (15 N., 8 E.).

In reviewing briefly the deposits of Hancock County we find the main deposits along the larger streams and in some kames in the civil township Brown. The barren areas comprise the western two-thirds of the civil townships Vernon, Buck Creek and Sugar Creek, the central part of Green, the northwestern half of Brandywine and the northeastern half of Jackson. Through the centers of all of these areas we find railroad transportation, by means of which a crushed limestone, which is more durable than the gravel, could be delivered within a few miles of where it would be used. For information regarding the cost, see page 156; for the quality see the results of tests on a number of samples of limestone from various parts of central Indiana made by the Road Testing Laboratory of the United States, on page 157; and an explanation of these tests on pages 64-79.

HAMILTON COUNTY.

Area in square miles	402
Population in 1900	29,914
Miles of public roads	700
Miles of improved roads	500
Percentage of roads improved	71.4
Miles improved with gravel	500

Miles improved with crushed stone	**None**
Average original cost of gravel roads per mile	**$1,200**
Total original cost o: improved roads	**$600,000**
Annual cost of repairs per mile on gravel roads 5 years old	**$50**
Miles of improved road (gravel) built in 1905	**12**
Miles of improved road (gravel) contracted for 1906	**9**
First improved roads built (toll)	**1865**
Proportion of improved roads built since 1895 (per cent.)	**20**
Satisfaction of farmers with investment in improved roads	**Good**
Authority	**N. W. Cowgill, County Auditor**

Hamilton, which is the center county of the State, forms a square of 400 square miles. It lies south of Tipton, west of Madison and Hancock, north of Hancock and Marion, and east of Boone and Clinton.

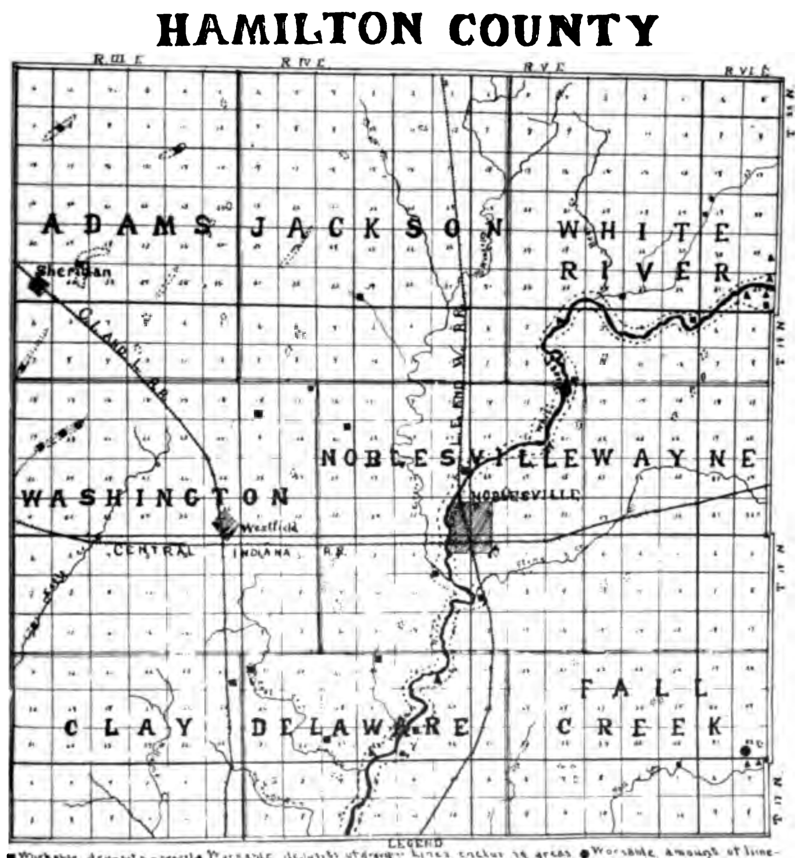

Fig. 38. Illustrating the distribution of road materials in Hamilton County.

Two geological epochs are represented in the surface rocks of the county, viz., the Niagara limestone of the Silurian, and the Wisconsin drift of the Pleistocene. The Niagara outcrops at only a few places in the county, the most extensive of these being at Connor's Mill, on White River, five miles above Noblesville, and at two small quarries southwest of Fishersville.

The topography of the eastern two-thirds of this county is nearly a level plain, except as it is traversed in the southeastern part by the valleys of White River and its tributary, Cicero Creek, which flows into it from the north, and Fall Creek, which cuts the southeastern corner of the county. The western portion of the county, because of a heavier covering of moraine, has an elevation ranging between 900 and 950 feet, while the elevation of the eastern portion is from 800 to 850 feet.

The main gravel deposits are located along White River, Fall Creek, and in old valleys which have been filled up, in the northwestern part of the county. For amount of gravel, Hamilton County falls below the average for central Indiana. An average for the rock percentages of the county would be 84 limestone, 10 crystallines, 4 shale, 1 chert, and 1 slate; and for the sizes, 8 per cent. clay, 15 per cent. fine medium sand, 16 per cent. medium sand, 20 per cent. coarse sand, 26 per cent. roofing pebble, 15 per cent. gravel, and 1 per cent. boulder.

The transportation facilities are only fair. The Michigan Division of the L. E. & W., running north and south, and the Midland, running east and west, intersect at Noblesville. The Chicago and Louisville cuts the southwest part of the county, and an interurban traction line passes north and south through Noblesville.

Township 20 North, Ranges 3, 4, 5, and Part of 6 East.

This area of 120 square miles which is found along the northern boundary of the county is poorly equipped for road material, the principal deposits lying along White River and in filled up stream valleys near and north of Sheridan.

In the civil townships of Adams and Jackson almost all of the gravel is taken from beneath the ground-water level by dipping, chaining and pumping; but in White River it is, for the most

part, obtained from dry pits. In Adams Township 60 per cent. of the roads are fairly well graveled, 20 per cent. being poorly improved, and 20 per cent. dirt. In Jackson, 25 per cent. are dirt, and in White River, 22 per cent. are dirt and 28 per cent. poorly graveled.

On the farms of A. Underwood, in the northeast quarter of section 32 (20 N., 3 E.); William Farrow, in the southeastern corner of section 29 (20 N., 3 E.); Eli Hutchins, in the southwestern corner of section 28 (20 N., 3 E.), and W. H. Cox, in the southwest quarter of section 28 (20 N., 3 E.), is a bed of gravel in an old valley which has long been filled up. This entire area has been tested more or less by driving a 1½-inch pipe, and is known to be underlain by gravel and sand under from 5 to 11 feet of stripping. On the Underwood place, where considerable material has been thrown out, a couple of locations have been tested for dipping where the depth is 25 feet and the stripping 5 feet. As one goes either north or south from these locations for dipping the stripping rapidly increases until it attains a thickness of 9 and 10 feet.

The sizes of the material are 10 per cent. clay, 12 per cent. fine medium sand, 25 per cent. medium sand, 15 per cent. coarse sand, 20 per cent. roofing pebble, and 18 per cent. gravel; and the rock percentages are 78 limestone, 16 crystallines, 4 shale, 1 chert, and 1 slate. The color is gray and the oxidation practically nothing. This material is sold at 45 cents per cubic yard. The roads on which it is used are very excellent, being hard, smooth and durable.

On the places belonging to John Burton, of the southwest quarter of section 8; J. H. Osburn, of the southeast quarter of section 7, and David McMurty, of the northeast quarter of section 8 (20 N., 3 E.), is another case where an old valley has been filled up with deposits of gravel, clay and sand. Tests have been made in this narrow strip for about 1 mile which show the gravel to be associated with large amounts of clay at most places. At a few points, however, it is workable, particularly on the John Burton farm, where it is being taken out by the endless chain process.

With this process, the stripping, which is from 3 to 5 feet, does not have to be taken off, but is allowed to fall into the pit and mix with the gravel; but it is not lifted out with it, because

Two geological epochs are represented in the surface rocks of the county, viz., the Niagara limestone of the Silurian, and the Wisconsin drift of the Pleistocene. The Niagara outcrops at only a few places in the county, the most extensive of these being at Connor's Mill, on White River, five miles above Noblesville, and at two small quarries southwest of Fishersville.

The topography of the eastern two-thirds of this county is nearly a level plain, except as it is traversed in the southeastern part by the valleys of White River and its tributary, Cicero Creek, which flows into it from the north, and Fall Creek, which cuts the southeastern corner of the county. The western portion of the county, because of a heavier covering of moraine, has an elevation ranging between 900 and 950 feet, while the elevation of the eastern portion is from 800 to 850 feet.

The main gravel deposits are located along White River, Fall Creek, and in old valleys which have been filled up, in the northwestern part of the county. For amount of gravel, Hamilton County falls below the average for central Indiana. An average for the rock percentages of the county would be 84 limestone, 10 crystallines, 4 shale, 1 chert, and 1 slate; and for the sizes, 8 per cent. clay, 15 per cent. fine medium sand, 16 per cent. medium sand, 20 per cent. coarse sand, 26 per cent. roofing pebble, 15 per cent. gravel, and 1 per cent. boulder.

The transportation facilities are only fair. The Michigan Division of the L. E. & W., running north and south, and the Midland, running east and west, intersect at Noblesville. The Chicago and Louisville cuts the southwest part of the county, and an interurban traction line passes north and south through Noblesville.

Township 20 North, Ranges 3, 4, 5, and Part of 6 East.

This area of 120 square miles which is found along the northern boundary of the county is poorly equipped for road material, the principal deposits lying along White River and in filled up stream valleys near and north of Sheridan.

In the civil townships of Adams and Jackson almost all of the gravel is taken from beneath the ground-water level by dipping, chaining and pumping; but in White River it is, for the most

part, obtained from dry pits. In Adams Township 60 per cent. of the roads are fairly well graveled, 20 per cent. being poorly improved, and 20 per cent. dirt. In Jackson, 25 per cent. are dirt, and in White River, 22 per cent. are dirt and 28 per cent. poorly graveled.

On the farms of A. Underwood, in the northeast quarter of section 32 (20 N., 3 E.); William Farrow, in the southeastern corner of section 29 (20 N., 3 E.); Eli Hutchins, in the southwestern corner of section 28 (20 N., 3 E.), and W. H. Cox, in the southwest quarter of section 28 (20 N., 3 E.), is a bed of gravel in an old valley which has long been filled up. This entire area has been tested more or less by driving a 1½-inch pipe, and is known to be underlain by gravel and sand under from 5 to 11 feet of stripping. On the Underwood place, where considerable material has been thrown out, a couple of locations have been tested for dipping where the depth is 25 feet and the stripping 5 feet. As one goes either north or south from these locations for dipping the stripping rapidly increases until it attains a thickness of 9 and 10 feet.

The sizes of the material are 10 per cent. clay, 12 per cent. fine medium sand, 25 per cent. medium sand, 15 per cent. coarse sand, 20 per cent. roofing pebble, and 18 per cent. gravel; and the rock percentages are 78 limestone, 16 crystallines, 4 shale, 1 chert, and 1 slate. The color is gray and the oxidation practically nothing. This material is sold at 45 cents per cubic yard. The roads on which it is used are very excellent, being hard, smooth and durable.

On the places belonging to John Burton, of the southwest quarter of section 8; J. H. Osburn, of the southeast quarter of section 7, and David McMurty, of the northeast quarter of section 8 (20 N., 3 E.), is another case where an old valley has been filled up with deposits of gravel, clay and sand. Tests have been made in this narrow strip for about 1 mile which show the gravel to be associated with large amounts of clay at most places. At a few points, however, it is workable, particularly on the John Burton farm, where it is being taken out by the endless chain process.

With this process, the stripping, which is from 3 to 5 feet, does not have to be taken off, but is allowed to fall into the pit and mix with the gravel; but it is not lifted out with it, because

the opened bottom and top of the chain buckets which carry the gravel out permits a circulation of water between the particles of gravel that washes away the dirt and a part of the clay. From 70 to 150 cubic yards of material are chained out daily.

The pit is from 22 to 28 feet deep, with a clay bottom. The material is gray in color and is unoxidized. The rock percentages are 80 limestone, 14 crystallines, 3 shale, 2 chert, and 1 slate; and the sizes, as taken from the mean of two samples, are 2 per cent. clay, 10 per cent. fine medium sand, 20 per cent. medium sand, 30 per cent. coarse sand, 30 per cent. roofing pebble, and 8 per cent. gravel. This low amount of clay does not allow the roads to become as well packed as if the amount was higher. Furthermore, a loose material works off at the sides of the roads and grinds up much more than when it is cushioned and held by matrix of clay. Since clay of a good quality can be supplied, the writer would suggest its addition. Eight thousand cubic yards of this material, at a cost of 40 cents each, are used in the annual repair of the roads for 6 miles north, 2½ miles west, 2½ miles east, and 4 miles south. These roads are smooth and durable.

Extending in a northeast and southwest direction, as was the case with the two preceding deposits, is a bed of gravel and sand about 500 yards long and with an average known width of 25 yards, in the northwest quarter of section 14 and the northeast quarter of section 15 (20 N., 3 E.), on the farms belonging to S. A. Vickory and A. Smith. At several places in this bed locations have been found for setting a gravel excavator, but for a general thing it is either too sandy, clayey or shallow. On the Vickory place, where 12,000 cubic yards of gravel have been dipped, the bed was from 20 to 45 feet deep and the stripping from 3 to 8 feet. Three hundred yards southwest of this point is another location that has as great a depth as 45 feet.

The quality of the material is below the average for that from beneath the water level. The sizes are 12 per cent. clay, 18 per cent. fine medium sand, 20 per cent. medium sand, 25 per cent. coarse sand, 20 per cent. roofing pebble, 4 per cent. gravel, and 1 per cent. boulder; the rock percentages are 78 limestone, 16 crystallines, 4 shale, 1 chert, and 1 slate; the color is gray, and the

oxidation almost nothing. Where used on the road it packs well and makes a smooth and hard road, but its fineness causes it to be less durable than if it were coarser.

On the land of Malissa Drake, of the northwest quarter of section 35; the W. E. Owens property, in the southwest part of section 35 and the southeast of section 34, and that of J. Reagan, in the southeast quarter of section 34 (20 N., 3 E.), is a bed of gravel, clay and sand apparently filling an old stream channel. The length is roughly 500 yards, the width 25 yards, and the depth and quality sufficient in places so that a few more locations for dipping have been found.

A small deposit is found on the G. W. Bean farm, in the south-central part of section 24 (20 N., 3 E.), and a bed of gravel underlying 2 or 3 acres, in the east-central part, on the land of Asa Wiles. At this place is a wet pit 200 yards long and 12 feet deep. The material taken out has the following rock percentages: Eighty limestone, 14 crystallines, 3 shale, 2 chert, and 1 slate; the sizes are 5 per cent. clay, 15 per cent. fine medium sand, 25 per cent. medium sand, 30 per cent. coarse sand, 15 per cent. roofing pebble, and 10 per cent. gravel; the oxidation is almost nothing and the color is gray. Although the roads on which this material is used are smooth and hard, they are not as durable as they would be if it were coarser.

Locations for dipping may be present on the farms of Henry DeVaney, of the southeast part of section 20 (20 N., 4 E.), in the flood plain of a small stream; and on the land of Martha McCarthy, in the southwest corner of section 29 (20 N., 4 E.). These two locations seem to connect with one another by a filling up of an old valley with gravel, sand and clay, as tests have shown, and to extend for ½ mile northeast of the DeVaney place. Tests for about 400 yards in a northeast and southwest direction on the DeVaney farm and the adjacent land to the east are said to show a number of points where the bed of gravel is over 18 feet thick and where a machine could likely be set. On the McCarthy place, a depth of 30 feet is claimed and a sufficient extent for setting a dipping machine.

In the southwest quarter of section 34 (20 N., 4 E.), on the L. N. Chew farm, is a ditch which shows a good depth of gravel

for 100 yards north and 100 west. At several points in its bottom tests have indicated a bed 17 feet thick. The stripping ranges between 3 and 7 feet. The sizes of the material are similar to those of southeastern Adams Township. The material, being for the most part beneath ground-water level, is very little oxidized.

On the places of D. Jacobs, in the southwest quarter of section 10, and that of M. Wilson, in the northwest quarter of section 10 (20 N., 4 E.), are gravel beds containing material whose sizes are 10 per cent. clay, 18 per cent. fine medium sand, 22 per cent. medium sand, 20 per cent. coarse sand, 25 per cent. roofing pebble, and 5 per cent. gravel. The former deposit is not workable on account of a very heavy stripping. The second has a tested extent of ½ acre beneath from 5 to 10 feet of surface. Beyond the ½ acre limit the stripping increases and the material grades into fine sand. The depth is from 10 to 20 feet, 3 feet of which is above water level.

Advancing eastward in this congressional township no other deposits of importance are found until Cicero Creek is reached, and none on this until we follow south to the bluffs and flood plains on the H. Klotz property, in the northwest quarter of section 30 (20 N., 5 E.). The bluff deposit contains from 4 to 7 feet of stripping, and a very small size of material, 10 per cent. being clay, 20 per cent. fine medium sand, 25 per cent. medium sand, 25 per cent. coarse sand, and 20 per cent. roofing pebble. Because of this heavy stripping and smallness of material, the deposit can hardly be termed workable. The flood plain deposit has not been opened, and is only known to underlie a few thousand square yards.

A small amount of gravel is taken from the flood deposits of Cicero Creek, in the northwest quarter of section 31 (20 N., 5 E.), on the Carson heirs' farm.

On the property belonging to Michael Schmitt, in the northeast quarter of section 4 (20 N., 5 E.), is a fair quality of gravel beneath the ground-water level. A tested location for dipping is said to be found here.

In the bluff of a tributary to White River, beneath from 2 to 4 feet of surface, is a bed of gravel on the John Criswell farm, in the southeast quarter of section 35 (20 N., 5 E.). This bed is

10 feet deep, with no bottom other than water, and has a known extent of 3,500 square yards. The sizes of material are about average, and the oxidation a little above.

Located in the bluff of Duck Creek in the southwest and northwest quarter of section 19 (20 N., 6 E.), on the places of Lewis Gwinn and Robert House, and in the southwest quarter of section 17 on the Samuel Templeton land, are some beds of gravel which have depths of about 10 feet and from 2 to 4 feet of stripping. The sizes and oxidation of material are about average. The amounts at the first two deposits are apparently workable, but the third is doubtful. At all of the beds the gravel often merges into a fine sand which can not be used.

In the bluffs of Fall Creek, on the property belonging to N. F. Foland, in the southeast quarter of section 29 (20 N., 6 E.), beside the road is a workable bed of gravel with a stripping ranging between 2 and 5 feet, and a depth of 12 feet with no bottom other than gravel. The color is brown and the sizes are somewhat below the average.

At numerous places along White River are workable deposits to be found in the terraces. Among some that have been opened are those on the farms of J. S. Hougham, S. B. Lee and L. C. Gentry, of section 32 (20 N., 6 E.). On the Hougham place dug well records show the following section: (1) Soil, 2½ feet; (2) till, 1½ feet; (3) gravel above water level, 8 feet; (4) and gravel beneath water level, 8+ feet. A large portion of the post holes over the 80 acre farm have reached gravel at their bottoms. The sizes are 7 per cent. clay, 12 per cent. fine medium sand, 21 per cent. medium sand, 32 per cent. coarse sand, 22 per cent. roofing pebble, and 6 per cent. gravel. One thousand loads at 12½ cents per cubic yard are used in the annual repair and building of roads for 4 miles east, ½ mile north, 1 mile west, and 2 miles south. The Lee deposit is also known to underlie a large area and to be similar in physical characteristics to the Hougham. The Gentry bed is found on the bank of an old water course between White River and Fall Creek. Its amount is workable and size about the average for the county.

A brief summary of this congressional township shows us that the eastern portion of the civil township, Adams, practically all of

Jackson, and the northern two-thirds of White River, will soon, unless some unknown deposits are discovered, have to obtain road material from outside sources. Because of the much better durability, the writer would suggest that crushed limestone be shipped to the most convenient points. To learn how the limestone of your own county compares with that of others, see how the tests made upon it, by the U. S. Road Testing Laboratory, compare with those made upon stone from other counties. In choosing a crushed limestone, the questions of quality and cost of transportation are the most important.

Township 19 North, Ranges 3, 4, 5, and Part of 6 East.

This rectangle, with a length from east to west of 20 miles and a width from north to south of 6 miles, occupies the central portion of the county. In the eastern part of this area are the main gravel deposits in the bluffs, terraces and flood plains of White River, and in the western portion are smaller deposits in old valleys that have been filled with gravel, clay and sand. These latter deposits are almost all beneath the ground-water level, while the former are, for the most part, above.

As in the township immediately north, great abundance of gravel is found in the bluffs and terraces of White River. On the farm belonging to L. P. Newton, in the northwest quarter of section 1 (19 N., 5 E.), is a workable bed of gravel, with a thickness above water level of 13 feet and an unknown one below, and with from 2 to 5 feet of stripping. The sizes of the material are about the average for the county. Other pits which contain workable amounts of gravel more or less mixed with fine sand are found on the second terraces of White River, in section 4 (19 N., 5 E.), on the W. Mosebaugh and D. Overdorf places; in section 9 (19 N., 5 E.), on the farms of M. Mosebaugh, Hannah Morris and W. F. Conway; J. G. Slusher, in the northwest quarter of section 21 (19 N., 5 E.), and in the flood plain on the W. H. Harrison farm, in the southeast quarter of section 20 (19 N., 5 E.). In addition to the pit gravel on the D. Overdorf place, 500 loads are obtained annually from the flood deposits of White River.

On the farm belonging to C. & N. Sylvester, in the northeast quarter of section 13 (19 N., 5 E.), is a bed of gravel with a thickness of 10 feet above ground-water level and at least 4 feet beneath, 3 feet of stripping, and a tested extent of 2,500 square yards. The sizes of the material are above the average.

In the southwest portion of this same section, on the farm belonging to J. Abney, is a bed beneath 3 feet of surface, with a depth of 8 feet. The area underlain has not been determined. The quality of the material is very good, the sizes being considerable above the average and the amount of oxidation not being very much. Five hundred cubic yards, at 40 cents each, are put on the roads annually for 2 miles east, 1/4 mile north, 1/2 mile west, and 1 mile south. A road running east and west past the pit was built 15 years ago from this gravel and today is in good condition with a small amount of repair.

In the southwest quarter of section 7 (19 N., 6 E.), on the place of W. H. Cray, is a deposit of gravel underlying to a greater or less extent 7 or 8 acres, as has been learned by turning the material up with the plow.

Another deposit is found on the W. H. Flanders place, on the side of a valley and in the flood plain in the northwest quarter of the same section. In the flood plain 2 or 3 acres are said to have been tested and found, under 2½ feet of soil, to be underlain with a bed of gravel which had a thickness of 4 feet above ground-water level and an unknown depth below.

On the lots belonging to F. M. Evans, beneath from 1 to 4 feet of stripping, in the northern part of Noblesville, is a bed of gravel on the second terrace of White River. The length of the deposit is 200 yards, the width 50 and the depth 3, as is seen from the exposure on the pit walls and tests made with a post auger. The sizes of the material are about the average and the amount of weathering higher.

One thousand cubic yards of gravel are obtained annually for repairing and building roads for 4 miles west, from the flood deposits along Cicero Creek, on the E. Metsker farm, in the southeast corner of section 35 (19 N., 4 E.), and 2,000 from that of C. and M. Horney, in the northeast quarter of the same section.

On the land belonging to N. C. Haworth, in the northeast cor-

ner of section 21 (19 N., 4 E.), is a morainic hill with an area of about 4 acres which is underlain with gravel and fine sand that frequently grade into one another. The depth is 10 feet and the stripping 5 feet. The mean of two samples gives about the average sizes of material. The rock percentages are also about average.

In the northeast corner of section 17 (19 N., 4 E.), on the Isaac Haworth place, on a valley side, is a workable deposit which is 2-3 gravel and 1-3 fine sand. Its depth is 10 feet and stripping 4 feet. The sizes of the material are 12 per cent. clay, 15 per cent. fine medium sand, 10 per cent. medium sand, 10 per cent. coarse sand, 23 per cent. roofing pebble, 20 per cent. gravel, and 10 per cent. boulder. The wearing quality is also above the average. Two hundred cubic yards, at a cost of 15 cents each, are used in the annual building and repair work.

In digging a ditch and making an excavation for a fish pond, on the Isaac Chance property, in the northwest quarter of section 29 (19 N., 4 E.), gravel was found in the bottom of the former for 15 rods, and to underlie $1\frac{1}{2}$ acres of the latter. The depth was not determined.

Small deposits are also known to occur on the farms of Charles Hiatt, in the northwest quarter of section 8, and in the south-central part of section 5 (19 N., 4 E.), on the farms of W. A. Perry and the Commack heirs.

On the W. W. Anderson place, in the south-central part of section 18 (19 N., 4 E.), is a bed of gravel and fine sand under from 2 to 7 feet of stripping along a stream bluff. An area 250 yards long and 30 yards wide seems to be underlain, as is indicated by a well 250 yards back from the bluff, that showed a stripping of 5 feet and a depth in the gravel of 5 feet and no bottom found. The depth along the bluff is 15 feet. The rock composition is average and the sizes of the material are above.

In the flood plain of a small stream beneath the ground-water level on the land of J. B. Foulke, in the northeast quarter of section 1 (19 N., 3 E.), is a bed of gravel underlying 3 or 4 acres which have been roughly tested, except in a place where a location has been found for setting a dipping machine. The bed rests upon a clay bottom and has a depth ranging between 15 and 40 feet. The material is about the average for size, with exception of 12 per cent. clay, and has a rock composition of 78 per cent.

limestone, 17 per cent. crystallines, 3 per cent. shale, 1 per cent. chert, and 1 per cent. slate. At a cost of 40 cents per cubic yard the material is put on the roads for 4 miles west, 4 miles north, 1 mile south, and ½ mile east. These roads are smooth, hard, and very durable.

On the Robert Inman place, in the northeast quarter of section 24 (19 N., 3 E.), is a bed of gravel with a depth of 10 feet which is partly above ground-water level and partly below, and a stripping ranging between 1 and 3 feet. This material is very much under size and considerably oxidized. It should be used only in very light repair work.

In the northwest quarter of section 10 (19 N., 3 E.), on the William Harrison farm, a considerable amount of a fine material has been dipped. The sizes are too small for building and heavy for repair work.

Beneath the ground-water level and under from 4 to 5 feet of stripping in the flood plain of a creek on the W. S. Swain land, in the northwest quarter of section 20 (19 N., 3 E.), is a bed of gravel resting upon a clay bottom with a thickness of 21½ feet at maximum. Two hundred and twenty feet either up or down stream from this maximum thickness the bed is only from 6 to 7 feet thick. The mean of two samples gives about the average sizes for the county. The rock percentages are 82 limestone, 10 crystallines, 5 shale, 3 chert, and 2 slate. The wearing quality is very good.

In a similar topographic position in the same creek, and in the northeast quarter of the same section, on the land belonging to Mary Newcomer, is a bed underlying from 2 to 5 feet of stripping, containing similar gravel but a very high content of clay. The depth is 40 feet at one place and the area underlain is 200 by 100 square yards. Although a great amount of material is available at this location, the clay makes it undesirable. Probably the endless chain process would give a cleaner gravel than the dipping.

A workable deposit under water level is found in the southeast quarter of section 19 (19 N., 3 E.), on the S. A. Paddock property. Twenty thousand cubic yards have been pumped out, which were used in building 4 miles of road. The depth to which the gravel was taken out was 22 feet and no bottom was found.

Without a doubt 30,000 cubic yards more can be obtained at this location.

In the vicinity of Eagletown considerable gravel is dipped from the creek bed. Eight and ten feet are the general depths of material.

A very extensive deposit is found in section 7 (19 N., 3 E.), traversing in a northeast and southwest direction the farms of W. Gillman, W. B. Jarrett, Watson Stahl, D. W. Hand, and Aaron Rawling, and that of John Stahl in the southeast quarter of section 6 (19 N., 3 E.). A man who assisted in testing this bed says that for 1½ miles northeast of the pit on the Gillman farm and ½ mile southwest the material, which was sand and gravel merging into each other more or less, was from 6 to 40 feet deep. The average width of the bed seems to be about 80 yards, but careful determinations as to this have not been made.

At the Gillman pit about 100 cubic yards are being taken out daily by exhausting the water with a pump and hauling the gravel out with wagons and horses. This exhaustion, the ground-water level being lowered 8 or 10 feet, shows that the bed is encased with clay or some other fine grained material and that this particular part of the deposit has not a great extent until it grades into this substance.

The quality of the material varies greatly, but probably an average of the gravel, excluding hardpan masses and fine sand, would give the following sizes: Nine per cent. clay, 15 per cent. fine medium sand, 20 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 13 per cent. gravel, and 1 per cent. boulder. The rock percentages are 85 limestone, 10 crystalline, 3 shale, 1 slate, and 1 chert.

Taking this congressional township as a whole, it is fairly well supplied with road material and very well provided with transportation to obtain it whenever it becomes necessary to depend upon outside resources. Up to the present the many flood plains and filled up valleys have only begun to be carefully tested. When this is done there is little doubt but that numerous other deposits will be found.

Township 18 and Part of 17 North, Ranges 3, 4, 5, and Part of 6 East.

This area, which comprises the southern 160 square miles of the county, has extensive deposits along the bluffs, terraces and flood plains of White River, and is also well supplied along Fall Creek and the larger streams of the part of the civil township, Delaware, which is west of White River; but further the deposits are small and seldom workable.

On the land belonging to the Gardner heirs, in the southwest quarter of section 7 (18 N., 3 E.), are 2 or 3 acres underlain with 4 feet of gravel above ground-water level and an unknown depth below. The stripping is 2½ feet. The rock percentages are about the average and the sizes of the material are a little below.

Similar deposits for rock percentages and amount of stripping are found in the west half of section 18 (18 N., 3 E.), on the farms of George Stultz, E. White, W. White and James Mount. All of these locations are found in the flood plain and first terrace. In the flood plain on the Stultz place no bottom to the gravel has been found and it has been tested to a depth of 7 feet below ground-water level. On the first terrace three openings have been made, the two end ones being ¼ mile apart. All of these show a bed of gravel and fine sand grading into one another. The thickness of the middle bed is 6 feet, and the sizes of the material are about average. The oxidation of the material is average for that above ground-water level and practically nothing for that below.

In the southeast quarter of section 24 (18 N., 3 E.), on the property of Thomas C. Owan, is an area of 250 by 250 yards, with a depth of 5 yards and a stripping ranging from 8 to 25 feet. The deposit would not be available except that the Chicago, Indianapolis & Louisville Ry. Co. took off the stripping over about 2 acres to make a fill. The quality of the material is extraordinarily good, because of a very calcareous clay or conglomerate, which is made up of very small pieces of rock with a calcium carbonate matrix. This cement is so pure that a large amount of the gravel comes out in great masses, which have to be blasted out. Often in the interstitial spaces of these masses, little stalactites and stalagmites are seen. When the material is put on the roads

it sets almost immediately, staying right where it is placed, whether on a hillside or on the level. The sizes of the material are a little below the average. Three thousand cubic yards, at a cost of 15 cents each, are used in the annual repair and building of roads for 5 miles west, 4 miles north, and 2 miles south.

As can be seen from the use of this material, little gravel is found to the west and south. The deposits that are found are very small and of a very poor quality.

Several workable gravel locations are found in a glacial ridge extending for ½ mile, about E. 10° S., in the southern part of section 6 (17 N., 4 E.). The most important location is on the land of John Wilkinson, where a pit section shows from 1 to 3 feet of stripping and a depth of 15 feet. As in most morainic deposits there are many abrupt changes in material, in some places being gravel and in others fine sand or clay. The material is about the average for size and amount of weathering. The color is a brown near the top and a gray at the bottom. The wearing quality is about average for a deposit above the groundwater level.

In the bluffs, terraces and flood plains of Coal Creek valley, which is ⅛ of a mile wide, are many workable deposits. Also the floods of this stream furnish considerable creek gravel. On the M. Wise place, in the northwest quarter of section 4 (17 N., 4 E.), a number of cubic yards are taken from the stream bars annually.

About 10 acres have been roughly tested by digging wells, post auger holes and plowing, and seem to be underlain by gravel and sand, in the stream bluffs and terraces of the northwest corner of section 4 (17 N., 4 E.), and the southeast corner of section 32 (18 N., 4 E.). The stripping over this area is from 1 to 5 feet, and the depth is not determined. A small pit opening 9 feet deep shows the sizes of material to be somewhat below the average and to run high in the fine medium sand. Considerable fine sand is also associated with the material, which makes the roads on which it is used sandy. Although this condition of roads exists in this vicinity, it can be easily avoided by screening the gravel as it is loaded.

In the flood plain of this same creek, in the southwest quarter of section 19 (18 N., 4 E.), on the farms of John Jeffries and

E. H. Collins, are some very probable locations for dipping. At several points on his flood plain, Mr. Collins has driven a pipe to a depth of 25 feet and was in a good quality of gravel all the way, without finding any bottom. The Jeffries flood plains are also known to be underlain by gravel, but the depth has not been determined.

On the A. E. Mendenhall place, in the northwest quarter of section 29 (18 N., 4 E.), and at a number of other points, workable quantities of gravel are reported along this valley, which will be opened as soon as the demand requires them.

On the L. O. Wise property, in the northwest quarter of section 33 (18 N., 4 E.), is a bed of gravel 13 feet deep and no bottom found, beneath from 1 to 2½ feet of stripping. This bed is in a kame, which is a frequent phenomena in this immediate locality. It stands from 10 to 20 feet above the adjacent region and comprises about 2 acres of surface. This material is about the average for size, and is coarser than that along the streams in this vicinity. The roads built and kept in good repair by it are smooth, hard, and durable.

In the northeast quarter of section 22 (18 N., 4 E.), on the place of S. Klingersmith, is a bed of gravel and fine sand extending for 250 yards along the bluff and 20 yards back of it, as is seen by a number of groundhog diggings. The depth is 13 feet and no bottom found, and the stripping from 1 to 4 feet. The sizes of the material are 9 per cent. clay, 13 per cent. fine medium sand, 5 per cent. medium sand, 20 per cent. coarse sand, 40 per cent. roofing pebble, 13 per cent. gravel, and 1 per cent. boulder, the fine sands and hardpan masses being excepted.

Occurring with a large amount of sand beneath from 1 to 4 feet of stripping in a stream bluff on the E. J. Vance place, in the northwest quarter of section 14 (18 N., 4 E.), is a deposit about 100 yards long and 50 wide, with a depth of 9 feet. The sizes of the material are a very little below the average, if the fine sand be screened out. Because of considerable oxidation, the quality would hardly be average.

On a level scope of land, in the southwest quarter of section 9 (18 N., 4 E.), on the farm of R. Shugart, the following tests have been made, which show a possibility of gravel and sand,

mostly beneath ground-water level, underlying about 20 acres: In the central part of the area at his pit Mr. Shugart went down for 25 feet and found under from 2 to 3 feet of stripping no bottom to the gravel; northeast of the pit 150 yards he dug a well to a depth of 33 feet with similar results; and 300 yards southwest of the pit he found, in digging his well at the house, 20 feet of gravel with a stripping of 8 feet, and no bottom other than gravel. On all sides of this area gravel is not reached until from 20 to 25 feet of clay are passed through. The material contains considerable fine sand and is slightly below the average in size. Six hundred cubic yards, at 15 cents each, are used in the annual repair and building of roads.

In a stream bluff on the land belonging to S. S. White, in the northwest quarter of section 9 (18 N., 4 E.), is a bed of gravel and sand which has been opened at 4 places and abandoned because of a heavy stripping. These openings, which follow the bluff for 1/4 of a mile, show a stripping of 1 foot at the bluff face and 8 feet 100 feet back. The material is a little below the average for size and frequently changes to a fine sand or clay.

An unstratified bed of gravel occurs in a small hill along a small stream valley, and stratified beds in the flood plain, in the southwest quarter of section 4 (18 N., 4 E.), on the place of C. J. Davis. Of the former deposits very little is known, with exception of an exposure in a small pit, which shows a depth of 7 feet with no bottom being found and a stripping of 3 feet. The sizes of the material are above the average, and the rock percentages are 83 limestone, 14 crystallines, 2 shale, and 1 chert. Three hundred cubic yards are used in the annual repair and building of roads for 1 mile north, 2 miles west, 1/2 mile east, and 1/2 mile south. The flood plain deposit has been found in the bottom of a ditch for some 40 rods. Mr. Davis, at several places in this ditch, drove a crowbar down into the material below ground-water level and found no bottom.

In the northwest quarter of section 12 (18 N., 4 E.), on the R. Farley property, is a surface 300 by 100 yards, and about 3 yards deep, which from pit wall exposures and some tests seems to be underlain by either gravel or fine sand, there being striking gradations between these. The stripping is from 1 to 3 feet and the

availability is very good. The sizes of the material are below the average, and the amount of weathering a little above.

As mentioned before, the larger deposits of the township are confined to the bluffs, terraces, and flood plains of White River. The flood plain and lower terrace deposits are almost continuous across the township, but are little used because of the better availability of those in the bluffs. Among the more important pit exposures are those of the bluffs on the farms of Mrs. C. E. Randolph, in the southwest quarter of section 7 (18 N., 5 E.), F. C. Eller, in the southwest quarter of section 35 (18 N., 4 E.), and James Eller, in the southwest quarter of the same section, and of the flood plains and lower terraces on the S. H. Moffitt place, of the southwest quarter of section 34 (18 N., 4 E.).

On the Randolph farm several acres have been tested and are known to be under 2 feet of soil. Nine feet of the bed is exposed at a small pit. The material is about the average for size and amount of weathering.

At the Black gravel bank 18 feet of gravel are seen beneath from 1 to 6 feet of surface. Since the deposit is found at several places along the bluff, and at the house the dug well is in gravel for 30 feet and no bottom found, it is probable that there is a large amount available at this place. Excluding the numerous lenses of fine sand and clay, the size is about an average and the oxidation a little below.

Beneath 2½ feet of soil, and with a similar depth and quality to that of the Black, are some very extensive deposits on the farms of F. C. Eller and James Eller.

The S. H. Moffitt bank, which is located in the first terrace deposit, and apparently has an extent of some acres, as rough tests indicate, shows a stripping ranging between 2 and 3 feet and a depth of 9 feet without finding bottom. The sizes of the material and amount of weathering are about average.

In the southwest quarter of section 24 (18 N., 4 E.), on the M. Maryfield farm, where the river makes almost a right angle in its turn from the north to the west, 1,000 loads of gravel are obtained annually from the stream bed. This material is little oxidized and is of about the average size.

For over an area of 7 or 8 acres in the flood plains of the same

farm the gravel comes almost to the surface and quite so in places.

On lots belonging to N. Teter and the Gascho heirs, just east of Noblesville, are some gravel beds which are claimed by tests to have shown a considerable extent of gravel. The writer did not see any good samples of the material.

In the flood plains and terraces of Stony Creek very few deposits of any economic importance are found. Beds from which a few thousand cubic yards of gravel, with average sizes and quality, can be obtained, are found on the M. Heiney place, of the northwest quarter of section 8 (18 N., 5 E.), and that of S. Haverstick, of the southeast quarter of section 4 (18 N., 5 E.).

In a kame on the land of David Israel, in the southeast quarter of section 3 (18 N., 5 E.), is a small bank deposit and a possible dip location of 2 acres which are known to be underlain because the dry pits were worked down to water level without any bottom to the bed being found. The depth of the bed above ground-water level is 8 feet and the stripping from 1 to 5 feet. The material of the dry pit contains a very high per cent. of fine medium sand, which has been used in repairing to a considerable extent, but is entirely too fine to make a hard and durable road. The rock percentages are 88 limestone, 8 crystallines, 2 shale, 1 chert, and 1 slate. One thousand two hundred cubic yards, at a cost of 10 cents each, are put on the roads for 5 miles east, 4 miles north, ¼ mile west, and 4 miles south. Because of this great demand, the writer would suggest that tests be made for either setting a dipping or endless chain machine. The quality of the material below water level will be considerable better than that above, since there is oxidation, which is very noticeable in the dry pit.

Beneath an average of 5 feet of stripping on the F. Bradley place, in the northwest quarter of section 10 (18 N., 5 E.), is a bed of gravel which seems to underlie about 2 acres of a kame. The few tests giving this information were such as plowing and digging with a post auger.

Another location is found in the northeast quarter of the same section, on the farm belonging to Mrs. Bush. Here a test showed a depth of 12 feet of gravel and no bottom, with a ½ foot of stripping. The extent of this deposit has not been learned.

For the improvement of roads in the civil township, Fall Creek, the greater amount of material comes from the terraces of Fall Creek valley. Among these terrace deposits are those on the L. Patterson farm, in the northeast quarter of section 5 (17 N., 6 E.), where 10 or 12 acres on the first terrace are underlain by a bed of gravel and sand which rests upon the limestone. This terrace is 250 yards from the stream, and is 200 yards wide. The depth of the gravel bed is 12 feet, and the stripping from ½ to 5 feet. The quality is above the average for the county, the sizes being 5 per cent. clay, 13 per cent. fine medium sand, 15 per cent. medium sand, 20 per cent. coarse sand, 30 per cent. roofing pebble, 16 per cent. gravel, and 1 per cent. boulder; and the rock percentages, 80 limestone, 12 crystallines, 5 shale, 2 chert, and 1 slate.

Other deposits in the southeast quarter of section 32 (18 N., 6 E.), on the M. Bell farm, and the north-central part of section 5 (17 N., 6 E.), on the M. Brooks place, are a continuation of the Patterson. At these, the quality and amount of gravel are sufficient, but the stripping is too heavy for the present demand.

On the property belonging to the De Camp heirs, in the northwest quarter of section 1 (17 N., 5 E.), is a splendid quality of gravel occurring beneath from 2 to 3 feet of surface, and having an extent of 8 or 9 acres, as is seen by its outcropping on the tops of several small hills and being exposed in the cellar under a house which lies between them. The pit exposure shows a depth of 14 feet and about the average sizes of material. One thousand cubic yards, at a cost of 15 cents each, are used in the annual repair of the roads for 5 miles north, 2 miles west, and 2 miles east.

Along Stoney Creek, on the land of James Kincade, in the northeast quarter of section 2 (17 N., 5 E.), is a workable deposit which has 3 feet of stripping and 15 feet of gravel that is very much below the average in size and is high in amount of weathering. A section shows: (1) Stripping, 3 feet; (2) gravel, 8 feet; (3) fine sand, 5 feet; (4) gravel, 2 feet.

On the Cynth Trittipo farm, of the northeast quarter of section 10 (17 N., 5 E.), is a deposit similar in material to the Kincade and of workable extent.

Deposits of very fine material are found in the northeast quarter of section 4 (17 N., 5 E.), on land belonging to Mrs. Gustin, and in the northwest quarter on the W. McKinstray place. The depths are 12 feet, the stripping from 2 to 5 feet, and the extents undetermined. Roads repaired by material from these deposits are sandy.

In a stream bluff in the northwest quarter of section 5 (17 N., 5 E.), on the property of T. N. Manship, is about 1 acre that has been tested by Mr. Manship with a post auger and found to be underlain with gravel. At the pit there is from 4 to 6 feet of stripping, a depth of 12 feet, and a clay bottom. The sizes of the material and rock percentages are about average. Six hundred cubic yards are used in the annual repair and building of roads for 3 miles north, 1 mile east, 2 miles south, and 1½ miles west. For packing and durability, the material is the best in the vicinity.

In the northwest quarter of section 22 (18 N., 5 E.), on the place of T. Clawson, is a tested location for setting a dipping machine. Three years ago material was obtained from this deposit to build the road running east and west past the old pit. The road today is smooth, hard and giving splendid satisfaction.

LIMESTONE.

Very few outcrops of limestone occur in this county, because of the heavy drift covering. Besides the outcrops at Connor's Mill and Fishersburg, mentioned in the introduction, there is one on the E. Lutz place in the southwest quarter of section 32 (18 N., 6 E.). All of these exposures present a hard, light buff dolomite.

At Connor's Mill the outcrop occurs for 200 or 300 yards below the dam, in the bed and along the banks of the stream. Although the depth has not been determined, it seems very probable that 50,000 cubic yards of stone and likely much more could be obtained at this place.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Tests of Niagara Limestone from Connor's Mill.**

Specific gravity	2.8	French coefficient of wear	8.1
Weight per cu. ft. (lbs.)	171.5	Hardness	13.8
Water absorbed per cu. ft. (lbs.)	1.08	Toughness	9
Per cent. of wear	4.9	Cementing value—Dry	15
		Wet	26

"Above the average in resistance to wear and cementing value, for dolomite. Best suited for light highway and country-road traffic."—Page.

A chemical analysis by the chemist of the Road Testing Laboratory shows the composition of the limestone to be as follows:

Chemical Analysis of the Niagara Limestone from Connor's Mill.

	Per cent.
Alumina (Al_2O_3)	.85
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	29.00
Magnesia (MgO)	16.94
Insoluble in hydrochloric acid	12.13
Loss on ignition	41.11
Total	100.28

Insoluble portion is silt.

TIPTON COUNTY.

Area in square miles	260
Population in 1900	19,116
Miles of public roads	560
Miles of improved roads	410
Percentage of roads improved	73.2
Miles improved with gravel	395
Miles improved with crushed stone	15
Average original cost of gravel roads per mile	$2,200
Average original cost of stone roads per mile	$3,500
Total original cost of improved roads	$921,500
Annual cost of repairs per mile on gravel roads 5 years old	$50
Miles of improved roads (gravel) built in 1905	28
Miles of improved roads (stone) built in 1905	4
Miles of improved roads (gravel) contracted for 1906	33
First improved roads built	1878
Proportion of improved roads built since 1895 (per cent.)	80
Satisfaction of farmers with investment in improved roads	Good
Authority	W. H. Marker, Cashier First National Bank, Tipton

*For standard of comparison see p. 79.

Tipton County is situated in central Indiana, immediately south of Howard and north of Hamilton Counties. The surface is a gently undulating till plain. There is a difference of 100 feet in altitude between the southwest and northeast parts, which is due to a difference in the thickness of the drift, it being from 200 to 300 feet thick in the southwest and from 75 to 100 feet in the northeast.

TIPTON COUNTY.

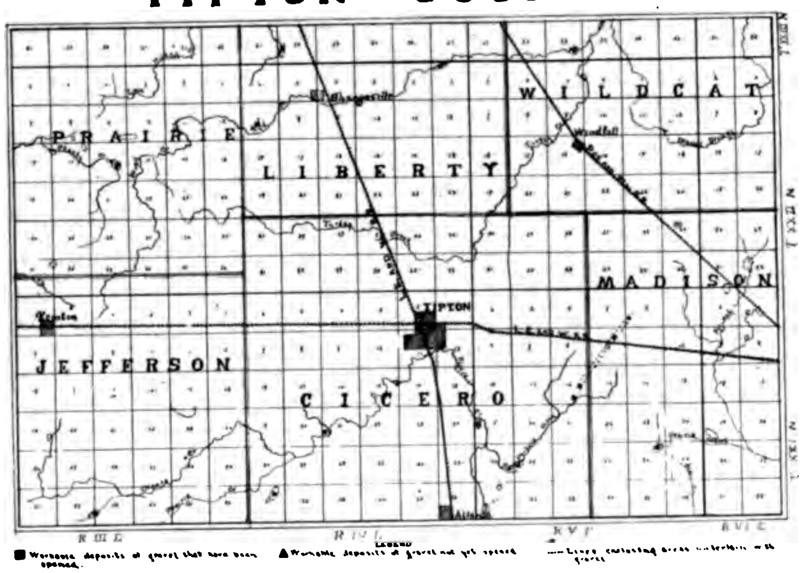

Fig. 39. Illustrating the distribution of road materials in Tipton County.

The railroad facilities of the county are fair, the Michigan Division of the L. E. & W., running north and south, and the main line of the same system, east and west, intersect at Tipton, and the P., C., C. & St. L. cuts the northeast corner. In addition, two interurban traction lines intersect at Tipton, one running north and south and the other east and west.

For amount and quality of gravel this county is one of the very poorest of central Indiana. The average sizes of the material are 7 per cent. clay, 23 per cent. fine medium sand, 23 per cent. medium sand, 20 per cent. coarse sand, 17 per cent. roofing pebble, and 10 per cent. gravel. The average rock percentages are 83 limestone, 10 crystallines, 4 shale, 2 slate, and 1 chert.

The deposits of economic importance in Tipton County are, with exception of two or three in hills along Mud Creek and one in the southeast corner, all below the ground-water level, and are operated by exhausting the water with a pump and then hauling the material out of the pits with teams. The main locations are along Shanty, Wildcat, Cicero, and Prairie Creeks, and old filled up valleys in the civil township of Madison.

Township 22 and Part of 23 North, Ranges 3, 4, 5, and Part of 6 East.

In the flood plain of Shanty Creek, beneath the ground-water level and resting upon a clay bottom, some fair deposits have been found on the L. Miller farm of the northwest quarter of section 17, on that of W. Scale in the central part of the same section, and on the property of C. Vanbriggle in the southeast quarter of section 16 (22 N., 3 E.). All of these are unweathered. The first deposit has a stripping of from 6 to 9 feet and the depth and extent are undetermined. The second bed is covered with from 5 to 7 feet of surface, has a depth ranging between 8 and 17 feet, but the extent is not known. Gravel that has been taken out has the following sizes: Three per cent. clay, 21 per cent. fine medium sand, 20 per cent. medium sand, 25 per cent. coarse sand, 18 per cent. roofing pebble, 10 per cent. gravel and 2 per cent. boulder. Two thousand cubic yards have been put on the roads for 3 miles south and ¾ mile east, and is giving splendid satisfaction. The third deposit has from 4 to 6 feet of stripping, a depth of from 3 to 18 feet, and a tested extent of 200 by 30 yards. The sizes of the material are 4 per cent. clay, 25 per cent. fine medium sand, 25 per cent. medium sand, 25 per cent. coarse sand, 15 per cent. roofing pebble and 6 per cent. gravel. Two thousand cubic yards of this material have been used on the roads for 6 miles south. The price charged per cubic yard is 10 cents, plus cost of lifting the material out, which is about 20 cents, thus making the total cost 30 cents per cubic yard, at the pit.

Under from 1 to 3 feet of stripping and resting on a clay bottom with a thickness ranging between 7 and 12 feet, is a bed of gravel, beneath ground-water level, on the W. H. Lee property in

the northeast quarter of section 17 (22 N., 3 E.). The extent over which the tests have been made are 150 by 100 feet.

By driving down pipe in an old swamp, which is now drained, S. Rodgers found on his farm in the southeast quarter of section 9 (22 N., 3 E.), a bed of gravel to underlie an area of 400 by 25 yards. It rests upon a clay bottom, has a thickness of from 7 to 12 feet and a stripping ranging between 2 and 5 feet. Where some material has been pumped, the mean of two samples gives the following sizes: Five per cent. clay, 28 per cent. fine medium sand, 25 per cent. medium sand, 20 per cent. coarse sand, 13 per cent. roofing pebble and 9 per cent. gravel. The amount of weathering, as in the case with almost all gravel beneath ground-water level in this vicinity, is practically nothing.

Beds of gravel, below ground-water level and resting upon a clay bottom, are found beneath from 2 to 5 feet of stripping in the flood plain of Broad Creek, on the farms of A. Rose in the west central part and F. Adams in the east central part of section 11 (22 N., 3 E.). The area known to be underlain on the latter is 150 by 50 yards, and the sizes of the material are above the average. The extent of the former is not determined, but the depth at one place is 8 feet, and the sizes of the material similar to the latter.

On the J. F. Mitt land in the southwest quarter of section 31 (22 N., 3 E.), is a bed of gravel resting upon a clay bottom and beneath 4 feet of surface. The depth is 9 feet and the extent, as learned by tests, is said to be 66 2-3 by 16 yards. Other small deposits in this locality, which have been pretty well exhausted, are found in the same section on the farms of C. Plough in the southeast quarter and Frank Miller in the northeast quarter, and in the northwest quarter of section 32 (22 N., 3 E.), on the J. E. Forkner place.

Another small deposit below ground-water level is found on the W. McIntyre land in the central part of section 27 (22 N., 3 E.), beneath the flood plain of Broad Creek.

In the flood plain of a tributary of Wildcat Creek in the west central part of section 32 (23 N., 4 E.), on the Becker and Wilson farms, is a bed consisting of one-third gravel and two-thirds fine sand, covered with from 2 to 6 feet of stripping and having

a clay bottom. The depth at the pit is 9 feet, and the area known to be underlain is about 4 acres. The sizes of the material, as taken from the average of two samples, are 10 per cent. clay, 13 per cent. fine medium sand, 14 per cent. medium sand, 14 per cent. coarse sand, 15 per cent. roofing pebble, 32 per cent. gravel, and 2 per cent. boulder; and the rock percentages are 82 limestone, 10 crystallines, 5 shale, 2 slate, and 1 chert. This deposit is worked by exhausting the water with a pump and then hauling the material out with horses.

Beneath the same flood plain in the northeast quarter of the southeast quarter of section 31 (23 N., 4 E.), 8 or 9 acres are reported to be underlain by gravel and fine sand, as is shown by the following tests. The bottom of a ditch is in the gravel for 350 yards. About 150 yards from this ditch a driven well is in the gravel for 18 feet, the stripping being 6 feet. Another well, 50 yards farther from the dtich, was driven 18 feet before reaching gravel. The writer would expect a very large per cent. of this deposit to be fine sand and would suggest very careful testing by driving a 1½-inch pipe before opening it up.

Occurring in a moranic hill, which is 25 feet above the adjacent region, in the southeast quarter of section 7 (22 N., 4 E.), on the Vanbiber land, is a deposit of gravel, above ground-water level, which underlies an area of 300 by 200 yards, as has been learned by tests. It rests on a clay bottom and has an average thickness of 5 feet. The sizes of the material, as taken from the average of two samples, are 5 per cent. clay, 23 per cent. fine medium sand, 16 per cent. medium sand, 16 per cent. coarse sand, 22 per cent. roofing pebble, 17 per cent. gravel, and 1 per cent. boulder; and the amount of oxidation is above the average. About 2,000 cubic yards of this material, at 15 cents each, are used in the annual building and repairing of roads, and gives good satisfaction.

Occurring in a morainic hill, in the northeast corner of section 10 and the southwest corner of section 3 (22 N., 4 E.), on some land belonging to the county, is a bed of gravel which probably contains several thousand cubic yards, with about an average size of material. Gradations of the gravel into fine sand and clay are frequent.

In a hill along Mud Creek on the land of Henry Roler in the northwest quarter of section 1 (22 N., 4 E.), is a deposit of gravel and sand underlying a surface of 200 by 30 yards, with from 3 to 7 feet of stripping. A section at the pit shows (1) stripping, 3½ feet; (2) fine gravel, 1½ feet; (3) fine sand, 2 feet; (4) gravel above the average in size, 3 feet; (5) very fine gravel, 3 feet. The depth ranges between 5 and 20 feet, and the bottom is clay. About 12,000 cubic yards were put on the roads in 1904 for 7 miles south. In the flood plain of Mud Creek between the Roler pit and the stream, gravel has been found in the bottom of a ditch for 250 yards.

A deposit of two-thirds fine sand and one-third gravel is found along Mud Creek in a hill near the center of section 33 (23 N., 5 E.), on the places of Rufus Plumber and William Kleyla. It underlies about 8½ acres, as appears by four pits being opened on the sides of the hill, so that they enclose an area of 350 by 100 yards. The depth ranges from 10 to 35 feet, the stripping is from 2 to 5 feet and the bottom is hardpan. An average of three samples gives the following sizes of the material: Five per cent. clay, 12 per cent. fine medium sand, 23 per cent. medium sand, 25 per cent. coarse sand, 15 per cent. roofing pebble, 19 per cent. gravel, and 1 per cent. boulder. This material is used in the building and repairing of the roads for seven miles both north and south, and where the coarser is used the roads are durable and are giving good satisfaction.

A bed of fine gravel, beneath ground-water level, is found in the flood plains of Mud Creek in the northwest quarter of section 34 (23 N., 5 E.), on the land of John Ogle. The depth at the pit is 18 feet, but the extent is not determined.

Beneath ground-water level, and under the flood plain of Turkey Creek, 150 by 150 feet are underlain with a bed of gravel, which has a depth of 15 feet and a clay bottom, in the southeast quarter of section 4 (22 N., 5 E.), on the property belonging to William Owens. Testing showed very abrupt changes from gravel to clay and fine sand. The sizes of the material, excepting fine sand and clay, are a little below the average of the county.

East and south of the Owens deposit, no known deposits of economic importance are known nearer than 7 miles. For this area,

as well as the southern halves of the civil townships of Liberty and Prairie, the writer would suggest that the shipping of crushed limestone, to the nearest railroad switch, be considered. Because of the distance that gravel is being hauled, the limestone, with its much greater durability, will probably be the cheaper and more satisfactory material.

Crushed limestone from the Nicoson quarry at Alexandria is, at present, being used on 4 or 5 miles of road at and north of Tipton. Roads a mile north and 2 miles east of Tipton are repaired by gravel that also comes from outside sources.

Township 21 North, Ranges 3, 4, 5, and Part of 6 East.

Deposits of gravel are known to exist beneath ground-water level on the Callaway farm in the northeast quarter of section 6, the Milligan place of the southwest quarter of section 5, and the Bess property in the northwest quarter of section 8 (21 N., 6 E.). The first is beneath from 2 to 6 feet of stripping and has a clay bottom.

In what appears to be a filled up stream valley, a deposit 400 yards long and 50 feet wide has been found by pipe driving in the southwest quarter of section 19 (21 N., 6 E.), on the Burkhart farm. This deposit is covered with from 2 to 4 feet of stripping, has a depth ranging between 2 and 14 feet, and rests on a clay bottom. The sizes of the material are small, being 8 per cent. clay, 20 per cent. fine medium sand, 35 per cent. medium sand, 30 per cent. coarse sand, 5 per cent. roofing pebble, and 2 per cent. gravel.

In the flood plain of Duck Creek in the southeast corner of the county is a bed of gravel partly above and partly below the ground-water level on the Massey place. It has from 2½ to 5 feet of stripping, a depth, at the pits, of 10 feet, and a clay bottom. The extent is not definitely known, but several pits, all showing a similar quality of gravel, have been opened, at various places, in a distance along the stream of 300 yards. The sizes of the material excepting fine sand and clay, are a little above the average. About 2,000 cubic yards are used in the annual building and repairing of roads. These roads are less sandy and better packed than the average in this part of the county.

In an old filled up stream valley running northeast and southwest from the Jackson place in the southwest quarter of section 2, diagonally across section 10, and to the south central part of section 16 (21 N., 5 E.), are a number of pockets of a rather fine and inferior material beneath the ground-water level. These pockets contain from 500 to 5,000 cubic yards, and merge frequently into a fine sand. All rest upon clay bottoms and have strippings ranging from 2 to 6 feet. An average of several samples gives the following sizes of the material: Fifteen per cent. clay, 35 per cent. fine medium sand, 35 per cent. medium sand, 10 per cent. coarse sand, 3 per cent. roofing pebble, and 2 per cent. gravel. The general color is gray.

Pits have been opened on the Jackson place of section 2, the Carr and Hartman of section 10, the G. Dillinger of section 16, the J. P. Foutch of section 16, and the L. Dillinger of section 21. On the Foutch farm the depth of the bed is from 1 to 15 feet, and the material is used for building and repairing the roads for about 6 miles in all directions. These roads are somewhat sandy and not as durable as those built with coarser material. In the southeast quarter of section 33 (21 N., 5 E.), on the John Renner land, is a small bed of gravel beneath from 2 to 5 feet of stripping. Extent and depth are not determined.

About 1½ acres have been tested on the property of M. Hobbs in the northeast quarter of section 26 (21 N., 5 E.), and are found to be underlain with a bed of fine gravel, beneath from 2 to 4 feet of surface. The depth ranges between 2 and 26 feet and the bottom is clay. This material is used on the roads for 2 miles north, 2 miles south, 2 miles east and 3 miles west. Like most of the roads of the civil township of Madison, they are sandy and not well packed. Small deposits of gravel are found on the Summer farm in the southwest quarter of section 31 (21 N., 5 E.), and on the Harran place in the northeast quarter of the same section.

In a filled up valley on the Meryncke place in the southwest quarter of section 29, Mr. Meryncke has tested an area of 500 by 50 yards, and found it to be underlain by a fine gravel. The stripping is from 1½ to 6 feet thick, the bottom is clay, and the depth is 18 feet at the center, but becomes less as the sides are

approached, where the gravel grades abruptly into clay. Some 6,000 cubic yards were pumped out in 1904 and used on the roads for several miles to the south, west, and north.

In the flood plain of Cicero Creek and beneath the ground-water level of the Cochran and Potts farms in the northeast quarter of section 24 (21 N., 4 E.), is a gravel bed, underlying, as is indicated by scattered tests, about 4,000 square yards. The stripping is from 2 to 4 feet, the depth ranges between 5 and 12 feet, and the bottom is clay. The sizes of the material are 6 per cent. clay, 25 per cent. fine medium sand, 35 per cent. medium sand, 20 per cent. coarse sand, and 14 per cent. roofing pebble.

A carefully tested area of 550 by 50 feet is located on the land of the Wiggins heirs, at the junction of Prairie Creek and a tributary, in the west central part of section 21 (21 N., 4 E.). Beyond the limits of this area tests show an abrupt change from gravel to clay. The bed has an average thickness of 10 feet, a stripping of 4 feet, and a clay bottom. The sizes of the material are 1 per cent. clay, 15 per cent. fine medium sand, 25 per cent. medium sand, 35 per cent. coarse sand, 17 per cent. roofing pebble, and 7 per cent. gravel; and the rock percentages are 73 limestone, 12 shale, 10 crystallines, 3 slate, and 2 chert. The quality of this material, because of its size and absence of oxidation, is one of the best of the county.

In the flood plain of a branch to Cicero Creek, beneath the ground-water level, are some gravel beds on the land of Henry Garhart in the northwest quarter of section 31 (21 N., 4 E.). The average thickness of these is 18 feet, the stripping from 3 to 4 feet, and the bottom clay. In an area of 125 by 70 yards, between 25 and 30 tests have been made by driving a pipe down, which shows depths ranging from 18 to 22+ feet. Beyond this area a few scattered tests have been made, which indicate that it is probable that an area of 250 by 100 yards is underlain with a sufficient depth of gravel for setting a gravel excavator or an endless chain apparatus. The sizes of the material are 1 per cent. clay, 15 per cent. fine medium sand, 20 per cent. medium sand, 30 per cent. coarse sand, 30 per cent. roofing pebble, and 4 per cent. gravel; and the rock percentages are 75 limestone, 10 shale, 10 crystallines, 3 slate, and 2 chert. With the Wiggins

material, this is the best quality in the county. There are, however, two objections to these materials. One is the high per cent. of shale, which is not a durable rock for road purposes, and the other is the low per cent. of clay. This makes the roads pack slowly, allows the gravel to work off at the sides, and the individual pieces to rub against one another. If 4 or 5 per cent. of clay could be carefully mixed with the gravel, it would wear longer and give better satisfaction.

Rather scattered tests have been made in the flood plain of a tributary to Cicero Creek, on the L. Spurgeon place in the southwest quarter of section 33 (21 N., 3 E.), which show an area of about 200 by 25 yards to be underlain with a bed of gravel, beneath ground-water level. This bed rests upon a clay bottom, has an average thickness of 15 feet, and a stripping ranging between 4 and 6 feet. The sizes of the material are a little below the average, and the rock percentages are 76 limestone, 9 shale, 11 crystallines, 2 slate, and 2 chert. About 1,000 cubic yards are used in the annual repairing and building of roads. As with the Garhart material, this gravel is too low in clay.

Below the flood plain of a tributary to Cicero Creek, in the east central part of section 19 (21 N., 3 E.), on the land belonging to J. H. Ferguson, is a bed of gravel beneath water level, underlying, as learned by tests, an area of 66 2-3 by 20 yards, with a depth of 20 feet and a stripping of 4 feet. A further extent has not been determined. The sizes of the material are rather fine, but 10 per cent. of clay aids it in packing and wearing on the roads. Rock percentages are 65 limestone, 20 shale, 5 slate, 8 crystallines, and 2 chert. Something like 4,000 cubic yards have been used in the annual repair and building of the roads for 3½ miles north and 4 miles east. These roads are well packed and smooth, but not as durable as they would be with a lower per cent. of shale and slate.

A possible location is found on the C. Ploughe property in the southeast quarter of section 19 (21 N., 3 E.), where a bed of gravel, with unknown extent, is known to exist beneath the ground-water level.

CLINTON COUNTY.

Area in square miles	402
Population in 1900	28,202
Miles of public roads	700
Miles of improved roads	460
Percentage of roads improved	65.7
Miles improved with gravel	460
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$2,100
Total original cost of improved roads	$966,000
Annual cost of repairs per mile on gravel roads 5 years old	$50
Miles of improved roads (gravel) built in 1905	10
First improved roads built	1880
Miles of improved roads built since 1895	115
Satisfaction of farmers with investment in improved roads	Good
Authority	E. O. Burget, County Auditor

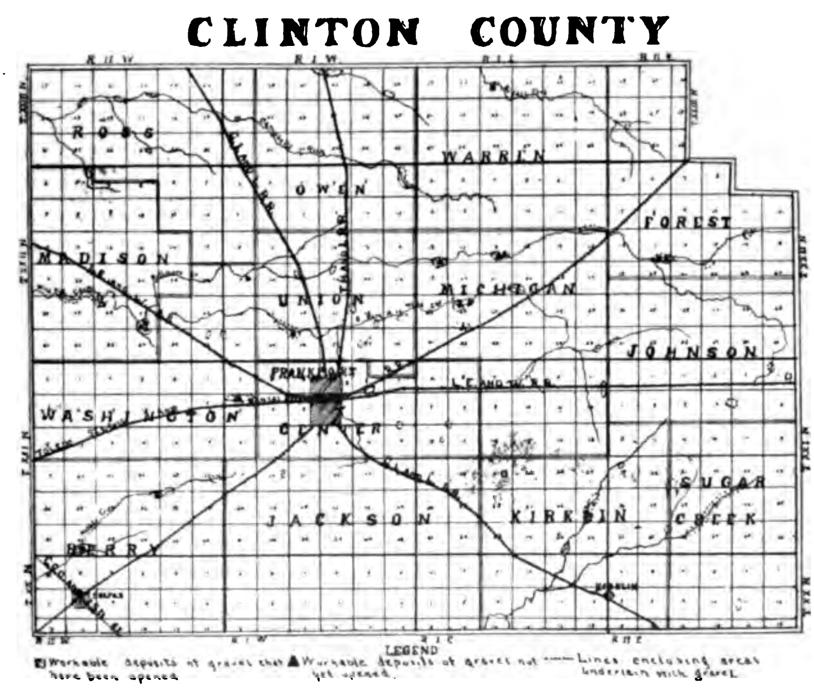

Fig. 40. Illustrating the distribution of road materials in Clinton County.

Clinton County lies north of Boone, east of Montgomery and Tippecanoe, south of Carroll, and west of Tipton and Hamilton Counties. The topography is that of a level plain gradually ris-

ing toward the southeast portion, where the drift attains a thickness of 300 feet.

The principal gravel deposits of this county are found in the bluffs, terraces and flood plains of Killmore and Wildcat Creeks, in the flood plains of Campbell's Run, Potato and Sugar Creeks, and in filled up stream valleys in the southeastern part of the county.

For amount of road material this county is somewhat below the average, but considerably better than Tipton. The quality of the material is about average, the sizes being, on the average, 6½ per cent. clay, 15 per cent. fine medium sand, 18 per cent. medium sand, 20 per cent. coarse sand, 26 per cent. roofing pebble, 13 per cent. gravel and 1½ per cent. boulder; and the rock percentages, 78 limestone, 11 crystallines, 7 shale, 1.5 chert, 1.5 slate, and 1 sandstone.

The transportation facilities are ample, the Vandalia, the Lake Erie and Western, the Toledo, St. Louis and Kansas City, and the Chicago, Indianapolis and Louisville diverge in all directions from Frankfort. An interurban traction line also passes northwest and southeast through Frankfort.

Township 22 and Part of 23 North, Ranges 1 and 2 West and 1 and 2 East.

This area comprises the northern half of the county. Its principal gravel deposits are found along Wildcat and Killmore Creeks, and Campbell's Run. Smaller beds are found along some of the small creeks and in old filled up stream valleys.

Numerous locations are present along Campbell's Run in the bluffs, terraces and flood plains, but the annual flood deposits are so large that very few pits have been opened. Many loads are obtained from the stream bars in the north central part of section 29 and the southeast corner of section 21 (23 N., 2 W.).

Several acres are underlain by gravel within 6 inches of the surface on the W. M. Beydler property in the northwest quarter of section 34 (23 N., 2 W.).

In the northeast corner of section 5, on the land of P. Rothenberger, is a bed of gravel, above ground-water level, in a hill along

a small tributary of Campbell's Run. The extent of the bed is known to be 100 by 25 yards; has a depth at the pit of 18 feet and no bottom found to the gravel, and a stripping ranging between 2 and 4 feet. The quality of the material is very good, the sizes being 4 per cent. clay, 8 per cent. fine medium sand, 7 per cent. medium sand, 13 per cent. coarse sand, 40 per cent. roofing pebble, 27 per cent. gravel, and 1 per cent. boulder.

Along Campbell's Run and under 5 feet of surface are beds of gravel on the W. F. Bell and Sims farms in the northwest quarter of section 1 (22 N., 1 W.). The former has been worked to a depth of 11 feet, where the ground-water level was reached, and the second reached this level at 8 feet. The latter is known by groundhog diggings and a few other excavations to follow the stream for 100 yards. The material of both deposits is a little below the average for size, and has the following rock percentages: Eighty-nine limestone, 7 crystallines, 3 shale, and 1 chert.

In a hill, which is partly on the P. W. Shaw place of the northwest quarter of section 7, and on the H. D. Bisel land of the southwest quarter of section 6 (22 N., 1 W.), is a bed of gravel beneath from 2 to 6 feet of surface, which underlies an area of 2 acres. At the pit, the depth is 18 feet and no bottom other than water has been reached. In rock percentages, amount of oxidation and sizes, with exception of the clay being 3 per cent., the material is about the average. The location of this deposit is exceptionally good because of a scarcity of road material for several miles in all directions. Roads built and repaired with it are very satisfactory, with exception of being slow in packing.

Probably the best localities for gravel in the county are those adjacent to Wildcat Creek. Many locations are found in its bluffs, terraces and flood plains, but only a few have been opened. In the bluffs of this creek in the southwest quarter of section 20, on the S. A. Slipher farm, the southeast quarter of section 20 on the Daniel Hock place, and on the J. Clendenning property in the northwest quarter of section 28 (22 N., 2 W.), are beds containing a material of average rock composition and a little below average for sizes. Abrupt gradations between the gravel and fine sand are common. The stripping ranges between 1½ and 4 feet.

On the Clendenning place an area of 6,000 square yards are un-

derlain by gravel, as shown by tests along the bluff, and post auger holes. The depth, at the pit, is 16 feet. A deposit 200 yards north underlies fully as much surface and has about the same depth.

Another deposit, similar in rock composition and sizes, is located in the bluff of Wildcat and along the road, in the southwest corner of section 21 (22 N., 2 W.). This bed also, as is seen by several excavations north and south, is probably workable. The depth, at the pit, is 17 feet, and no bottom reached, and the stripping ranges between 1 and 4 feet.

In the south central part of section 27 (22 N., 2 W.), on the land of Mary Stafford, is a bed of gravel in the bluff of a small tributary to Wildcat Creek. This bed can readily be traced in the bluff for 350 yards, which brings one to the junction of the tributary and Wildcat. By advancing east about 200 yards along the bluff of Wildcat Creek one comes to the H. A. Wallace pit, where a similar quality of material is found to that on the Stafford, both being almost the average for rock percentages and a little below for sizes. Since the gravel can be traced around the bluff, it is barely possible that the intervening area is also underlain by either gravel or sand, as kettle basins between these will not hold water, even after a heavy rain. If this connection exists there would be an area of 10 acres underlain by gravel. At the Stafford pit the stripping is from 3 to 5 feet, the depth 20 feet and no bottom reached, while at the Wallace the bed rests upon a clay bottom, has a thickness of 17 feet and a stripping ranging between 2 and 3 feet.

In a bluff in the north central part of section 36 (22 N., 2 W.), on the property of E. H. Knapp, a bed of gravel, resting upon a fine sand bottom, has, at the pit, a depth of 17 feet and a stripping of from 2 to 4 feet. For 80 yards along the bluff the deposit is found to occur, and 150 feet south of the bluff at the house a dug well showed 7 feet of stripping and 18 feet of gravel. These evidences apparently give an extent of 150 by 80 yards. Excepting a number of lenses of fine sand, some having lengths of 20 feet and diameters at the center of 2 feet, the average of two samples gives the following sizes: Six per cent. clay, 10 per cent. fine medium sand, 14 per cent. medium sand, 15 per cent.

coarse sand, 29 per cent. roofing pebble, 25 per cent. gravel and 1 per cent. boulder. The rock percentages are about average, and the amount of weathering below for the material above groundwater level. This material is used for ¼ mile north, 3 miles east, 7 miles south and 1 mile west in building and repairing the roads, which, where they have been properly attended to, are hard, smooth, durable and giving the best of satisfaction.

In the bluff of Wildcat in the southeast quarter of section 29 (22 N., 1 W.), on the Dewitt place, is a deposit of gravel beneath from 2 to 3 feet of surface and with a depth of 15 feet, at the pit, underlying an area of 100 by 25 yards. The sizes of the material and the oxidation are about average.

In the northwest corner of section 33 (22 N., 1 W.), on the Cohler farm, is a bed of gravel in the bluff of a tributary to Wildcat Creek. The extent of this bed is known to be 150 by 30 yards, the depth 12 feet at the pit, and the stripping from 2 to 3 feet. The sizes of the material are about average. Besides the Cohler and Dewitt deposits there are a number of others, reported in this vicinity, along the bluffs, terraces and flood plains of Wildcat.

Several acres, as learned by scattered tests, are underlain by gravel on the J. L. Black property in the northeast quarter of section 19 (22 N., 1 W.). This bed, at the pit, has a depth of 20 feet, a stripping ranging between 1 and 4 feet and a material below the average for sizes. The material, where it has been used on the road, is very low in clay and is slow to pack. Groundhog diggings and other excavations show gravel at a number of places in the bluffs of this neighborhood. Careful tests would very likely locate some other workable deposits.

About two miles east of the Black deposit and in the bluff of the same stream is a bed of two-thirds gravel and one-third fine sand on the land belonging to N. Burris in the northwest quarter of section 21 (22 N., 1 W.). This bed, as has been learned by groundhog diggings, seems to follow the bluff for 300 yards, and at the pit extends back 50 yards from the face of the bluff. The bottom of the bed has not been found, and it has been worked to a depth of 15 feet. The stripping ranges from a few inches to 3 feet. The sizes of the material, excepting fine sand, are above the average and the oxidation below.

In a flood plain in the west central part of section 35 (22 N., 1 W.), on the place of Cicero Sims, is a bed of fine gravel beneath ground-water level with a depth, at the pit, of 20 feet. The extent is unknown. A sandy, considerably oxidized and shallow bed of gravel is found, beneath from 2 to 5 feet of stripping, in the bluffs of the South Fork of Wildcat Creek, on the farms of C. Lee and B. D. Parvis in the southeast quarter of section 25 (22 N., 1 W.).

One and one-half miles east of these deposits on the farm of I. C. Michaels, in the northwest quarter of section 29 (22 N., 1 E.), a number of tests, by driving a 20-inch pipe down, have indicated that an area in the flood plain of 250 by 150 yards are underlain by a bed of gravel, beneath ground-water level and having from 2 to 3 feet of stripping. No bottom was found. From a few tests made by the writer a material was obtained that had the following sizes: Two per cent. clay, 5 per cent. fine medium sand, 14 per cent. medium sand, 30 per cent. coarse sand, 30 per cent. roofing pebble, and 19 per cent. gravel; and the rock percentages were 70 limestone, 16 shale, 8 crystallines, 4 slate, and 2 chert. This material, with exception of being low in clay, which will make it slow in packing, and being high in shale, which is not durable, is a very good road material, being of a good size and unoxidized. Furthermore, it is located in a vicinity where gravel is very scarce and is often hauled for several miles. Another location for obtaining gravel from beneath the flood plain of this same stream is found 2 miles east of the Michaels place on the Goodnie farm. The extent and depth of this deposit is not well determined.

In the north central part of section 32 (22 N., 1 E.), on the William Gangwer place, is a bed of gravel beneath ground-water level and beneath the flood plain of a tributary to the North Fork of Wildcat Creek. This bed is near the road, rests upon a clay bottom, has a depth ranging between 6 and 20 feet, a stripping of 2 feet and an extent, as a number of tests have indicated, of 70 by 450 yards. The sizes of the material, at the pit, are about the average, except for 2 per cent. clay, and the rock percentages are 70 limestone, 16 shale, 8 crystallines, 4 slate, and 2 chert. About 4,000 cubic yards of this material are used in the annual build-

ing and repairing of the roads. These roads are slow to pack but are durable.

In the bluff of a small stream, in the northeast quarter of section 22 (23 N., 1 W.), on the Kempler farm, is a deposit of fine gravel and fine sand, grading into one another. Beneath ground-water level and in the flood plain of this same stream is a bed of gravel in the southwest corner of section 24 (23 N., 1 W.), where 8 feet of gravel have been found. A gravel excavator was set at this location, but the depth of material was not sufficient. Possibly the water level could be lowered with a pump so that it might be worked the same as a deposit above the ground-water level.

The only known gravel deposit in the civil township of Warren, that is of any practical importance, is found beneath the flood plains of the Middle Fork of Campbell's Run, on the place belonging to F. M. Tisen in the southeast quarter of section 21 (23 N., 1 E.). This deposit is beneath ground-water level, has a stripping of from ½ to 3 feet and a depth at the pit of 18 feet. The area underlain is 200 by 200 yards, as scattered tests have indicated. The sizes of the material are 9 per cent. clay, 20 per cent. fine medium sand, 20 per cent. medium sand, 20 per cent. coarse sand, 10 per cent. roofing pebble, 18 per cent. gravel, and 3 per cent. boulder. The rock percentages are 85 limestone, 8 crystallines, 3 chert, 3 shale, and 1 slate. Because of its clay, which makes it pack quickly, and its unoxidized condition, this material makes a durable and satisfactory road.

On the Maxwell farm in the southeast quarter of section 18 (22 N., 1 E.), in the flood plain of Killmore Creek and beneath from 2 to 5 feet of stripping, six feet of gravel are found, 2 feet of which are below and 4 feet above water level. The area underlain, as learned by rough tests, is 200 by 50 yards. The sizes of the material are very much below the average and gradations into fine sand are found in places.

About 1¾ miles east, in the flood plain of the same stream, gravel deposits occur on the S. Loucke, Shoemaker and Brandy farms in the southeast quarter of section 16 (22 N., 1 E.). On the Loucke place, the depth ranges between 6 and 12 feet, the stripping is from 2 to 4 feet and the extent, as a few tests show, may be 150 by 150 yards. The sizes of the material are about

like those of the Maxwell deposit. On the Shoemaker and Brandy places, the flood plain is known at a few places to be underlain by gravel, but neither the extent nor the thickness of the bed are known.

As we advance eastward along the flood plain of this stream, gravel is reported to be present in a number of places, especially in the north central and the northeast parts of section 13 (22 N., 1 E.); but it has not been carefully tested or worked, to any extent, until we reach the H. Davis property in the southeast quarter of section 17 (22 N., 2 E.). At this place an area of 200 by 400 yards is said to have been tested by pipe driving, and is known to be underlain with gravel and sand to a depth ranging between 10 and 50 feet. For 4 miles both north and south this material is used in the building and repairing of roads, which, when taken care of, are smooth and durable.

A material, which frequently grades into fine sand, is found in the flood plain of the same stream, below water level, in the northwest corner of section 22 (22 N., 2 E.), on the land belonging to D. A. Coonrod. The stripping, at the pit, ranges between 3 and 6 feet and the depth between 6 and 16 feet. An area of 30 by 100 yards has been tested and is said to be underlain by gravel. The sizes of the material are much smaller than the average.

In the west central part of section 31 (22 N., 2 W.), on the place of A. N. Spurgeon, is a bed of fine gravel, beneath 3 feet of surface and the ground-water level, with a depth of 18 feet, and a tested extent of 20 by 50 yards.

Township 21 and Part of 20 North, Ranges 1 and 2 West and 1 and 2 East.

Almost all of the gravel in this area is found beneath the ground-water level, in stream valleys that have been partially or entirely filled up.

Gravel is found beneath the flood plain of a tributary of Kill-more Creek, on the Sievers place in the northwest quarter of section 1 (21 N., 2 E.). The stripping is 4 feet, but the extent and the depth are not known.

Gravel a little below the average for size is located in an old swamp on the Cowder place in the east central part of section 10,

and the Wood place in the west central part of section 11 (21 N., 2 E.). This deposit is below the ground-water level, rests upon a clay bottom, has $3\frac{1}{2}$ feet stripping and a depth ranging between 8 and 20 feet. The extent, as indicated by a few scattered tests, is probably 75 by 200 yards.

A number of fair pockets of gravel are known to exist in an old filled up valley, and have been opened up on the farms of George Alexander in the northwest quarter of section 26, W. Clidence in the northeast quarter of section 27, Mr. Boyer in the southwest quarter of section 27, and William Price in the east central part of section 33 (21 N., 2 E.). At all of these pits the gravel is below the ground-water level, rests upon a clay bottom, has from 2 to 5 feet of stripping, and a depth ranging between 15 and 20 feet. The material is a little below the average for size and has the following rock percentages: Seventy-three limestone, 13 shale, 10 crystallines, 2 chert, and 2 slate. The extent, on the Alexander place, is small; on the Clidence, it is known by tests to underlie an area of 20 by 200 yards; on the Boyer a location for setting a gravel excavator is known, and on the Price only a very limited area has been found to be underlain. The roads built and repaired with this material are smooth and fairly durable, but are slow to become packed. Careful testing will, undoubtedly, give other practical locations along this old filled up valley. Several locations are also reported for setting a gravel excavator in the southwest quarter of section 11 (20 N., 2 E.), on the Stauers land.

In the southwest corner of section 28 (21 N., 2 E.), on land belonging to George Price, is a bed of gravel in a filled up valley. This bed rests upon a clay bottom, has a thickness of 15 feet and a stripping of $3\frac{1}{2}$ feet. Three locations for setting a gravel excavator are reported.

In a filled up valley in which a fork of Sugar Creek has its present channel are a number of small deposits. Some of these are found on the Howe place in the south central part of section 24, on the Winecup and Cox places in section 25, and on the Furguson in the south central part of section 35 (21 N., 1 E.). All of these beds rest on clay bottoms, are beneath ground-water level and contain material that is considerably below the average

for sizes. On the Howe place the depth is from 8 to 20 feet, and by detailed testing one location has been found for setting a gravel excavator. On the Cox farm and the place immediately south, careful pipe tests have been made for 500 yards along the stream, and the results were one location 150 by 250 feet, with an average depth of 20 feet. A small deposit of a fine material is found below the ground-water level in the southeast corner of section 1 and the northeast corner of section 2 on the Bernett farm.

In an old swamp in the southeast quarter of section 21 (21 N., 1 E.), on the Clark property, is a bed of gravel underlying an area of 23 by 90 yards. It rests upon a clay bottom, has a depth of 12 feet and a stripping of 5 feet. The sizes of the material are about average, except that the clay is only 3 per cent. The rock percentages are 74 limestone, 11 crystallines, 10 shale, 3 chert, and 2 slate; and the amount of weathering is practically nothing. With the exception of not having sufficient clay to pack readily, this gravel is of a splendid quality for this locality.

Beneath the ground-water level, in the northeast quarter of section 18 (21 N., 1 E.), on the Maish farm, is a bed of gravel resting on a clay bottom, and having a stripping of 4 feet and a depth ranging between 6 and 15 feet. The sizes of the material are 9 per cent. clay, 20 per cent. fine medium sand, 23 per cent. medium sand, 35 per cent. coarse sand, 10 per cent. roofing pebble, and 3 per cent. gravel. The extent is not known.

A bed of gravel, beneath ground-water level, is found in East Frankfort on the property belonging to R. N. Stone. The stripping is from 1 to 3 feet and the depth, at the pit, is 15 feet. An area extending 250 yards north of the pit and having a width at one place of 80 yards is known by tests to be underlain with gravel, but the depth has not been determined.

In the flood plain of a stream on the land belonging to S. Carr in the northeast corner of section 1 (21 N., 1 W.), a bed of gravel has been found, by digging down at four or five places with a spade, to underlie the surface. Further tests have not been made. In the northern part of section 7 (21 N., 1 W.), a county ditch has its bottom in the gravel, more or less, for 800 yards. The depth or further extents have not been determined. The sizes vary from a very fine gravel, which grades into fine sand, to a

material above the average. The rock percentages are 68 limestone, 15 shale, 10 crystallines, 5 slate, and 2 chert. This location would be an especially good one, because no known deposits are nearer than 2½ miles.

Some very fair deposits have been found beneath the flood plain of Potato Creek. Among these are those on the Anderson place in the southwest quarter of section 24, the Dukes and William Harshman farms in the northwest corner of section 26, and the property of J. Coyner in the south central part of section 32 (21 N., 2 W.).

On the Dukes place the bed is 9 feet deep, but sufficient extent has not been found for setting a gravel excavator. The gravel that was dipped out contained a very high percentage of clay, which was considered very detrimental. However, 11 or 12 per cent. of clay is generally beneficial to a gravel, as it assists it in packing quickly and keeps the particles cushioned from one another so that the grinding is greatly lessened. It also holds the material on the roads, so that it is not necessary to be continually grading in order to keep it on. The sizes of the material for the deposit are 25 per cent. clay, 15 per cent. fine medium sand, 20 per cent. medium sand, 15 per cent. coarse sand, 15 per cent. roofing pebble, 8 per cent. gravel and 2 per cent. boulder.

At the Harshman bed a gravel excavator was set, but was taken away because of the high percentage of clay. Subsequently an endless chain apparatus was set, which is lifting out a very good quality of material. The sizes are 11 per cent. clay, 20 per cent. fine medium sand, 17 per cent. medium sand, 20 per cent. coarse sand, 20 per cent. roofing pebble, 8 per cent. gravel and 4 per cent. boulder. The rock percentages are about the average for the county. The tests of the *gravel excavator and the endless chain apparatus at this pit give one a good idea of how the latter machine washes the finer material out of the gravel, and how it is possible to use it where the excavator can not be used.

The Coyner deposit is located in the flood plain between Potato Creek and a tributary, near their junction. Ten acres have been roughly tested, and several locations for setting a gravel excavator in detail. Where the gravel was dipped it was taken out to a

*See page 124.

depth of 40 feet and no bottom was found. The stripping ranges from 2 to 4 feet. The sizes of the material are 8 per cent. clay, 25 per cent. fine medium sand, 22 per cent. medium sand, 15 per cent. coarse sand, 15 per cent. roofing pebble, and 15 per cent. gravel; and the rock percentages are 70 limestone, 12 shale, 10 crystallines, 3 slate, 3 sandstone, and 2 chert. Where this material has been put on the roads it packs well and makes a smooth, hard and durable road.

A bed of gravel containing lenses of fine sand occurs in the east central part of section 7 on the Hayes place. Tests have indicated a length of 150 yards, a width of 10 yards, a depth ranging between 10 and 15 feet, and a stripping from 3 to 5 feet. The sizes of the material are 12 per cent. clay, 35 per cent. fine medium sand, 18 per cent. medium sand, 15 per cent. coarse sand, 10 per cent. roofing pebble, 8 per cent. gravel, and 2 per cent. boulder; and the rock percentages are 69 limestone, 12 shale, 10 crystallines, 5 sandstone, 3 slate, and 1 chert. Although this material is too fine for good satisfaction, it is the only deposit known of within 3½ miles of this locality, and because of its availability is the cheapest for the immediate vicinity.

In closing the remarks for Clinton County the writer will say that in those localities in which gravel has to be hauled for several miles, or where it is of a poor quality, such as in the northern part of the civil township Owen, eastern and southern Warren, southern Johnson, eastern and southern Michigan, northern Kirklin, all of Jackson, southeastern Perry and southern and central Washington, it would be well to investigate as to the cost* of getting crushed limestone, which is a more durable road material than gravel, to the nearest railway or traction line switch. The results of †tests on various limestones of central Indiana by the Road Testing Laboratory of the United States, given in this report, might be of service in determining the wearing quality.

*See page 154.

†See page 156. An explanation of these tests is found on page 74.

BOONE COUNTY.

Area in square miles	427
Population in 1900	26,321
Miles of public roads	816
Miles of improved roads	600
Percentage of roads improved	73.5
Miles improved with gravel	600
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,200
Total original cost of improved roads	$720,000
Annual cost of repairs per mile on gravel roads 5 years old	$54
Miles of improved roads (gravel) built in 1905	6
First improved roads built	1880
Miles of improved roads built since 1895	100
Satisfaction of farmers with investment in improved roads	Good
Authority	Benj. F. Simmons, County Auditor

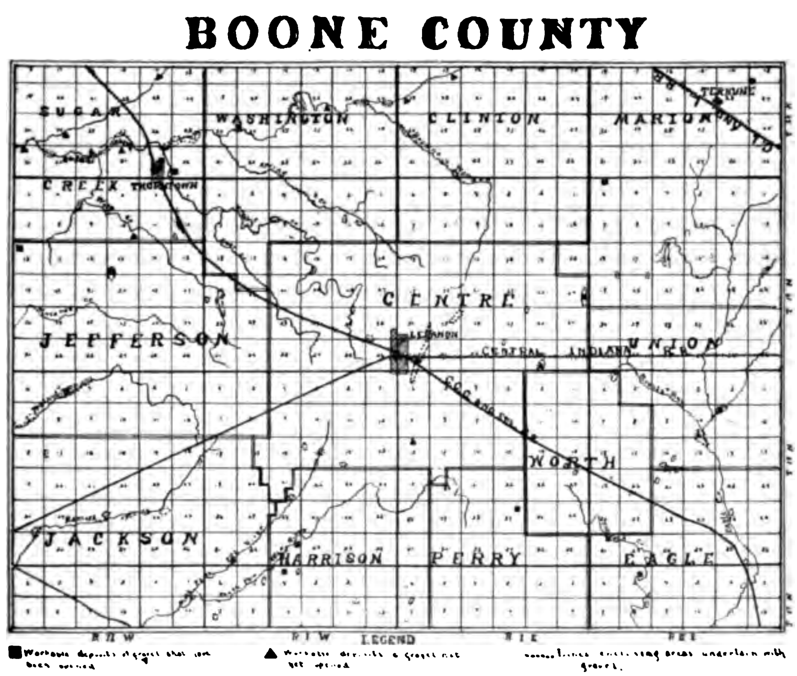

Fig. 41. Illustrating the distribution of road materials in Boone County.

This County is situated near the central part of the State, lying south of Clinton, west of Hamilton, north of Marion and Hendricks, and east of Montgomery. In shape it is a rectangle, with

a length from east to west of 24 miles, and a width from north to south of 17½ miles.

The topography is that of a level plain, broken by an occasional gentle swell, which scarcely exceeds 20 feet in height, and a few kame deposits in the northwestern part of its area. The main part of the gravel deposits is found in the bluffs, terraces and flood plains of the larger streams, and a smaller portion in old filled up stream valleys and kames. For amount of gravel this county is about the average for central Indiana.

The quality of the gravel is somewhat below the average, because of such a low percentage of clay, which causes it to pack slowly, work off at the sides of the road and grind up more rapidly than it would if it contained a higher percentage. The average sizes of the material are 4½ per cent. clay, 10 per cent. fine medium sand, 16 per cent. medium sand, 26 per cent. coarse sand, 27 per cent. roofing pebble, 15 per cent. gravel and 1½ per cent. boulder; and the rock percentages are 81 limestone, 9 crystallines, 6.5 shale, 2 slate, 1 chert, and .5 sandstone.

The transportation facilities are very fair, the Chicago Division of the Big Four traversing the county diagonally from the southeast corner to the northwest corner, crosses at Lebanon the Chicago and Southwestern, which crosses the county from east to west, and the Wabash cuts the northeastern corner. The interurban traction lines extend out from Lebanon in three directions—to the north, to the southeast, and to the southwest.

Part of Township 20 North, Ranges 1 and 2 West, and 1 and 2 East.

The deposits of this township are almost all found in the bluffs, terraces and flood plains of the larger streams. Especially is this true with Sugar Creek, whose bluffs and terraces form almost a continuous deposit of gravel and fine sand from where it enters the county, three miles northeast of Mechanicsburg, until the point of leaving, 4½ miles west of Thorntown.

Mixed with numerous fragments of a shaly limestone is a bed of gravel along Sugar Creek on the W. O. Daggy farm, in the northwest quarter of section 31 (20 N., 2 W.). This bed is cov-

ered by one-half foot of stripping and is workable. The fragmental limestone makes the material very coarse, and the roads built by it are rough at first, but when they become packed and worn down a little they are very satisfactory.

For 300 yards along a valley side on a tributary to Sugar Creek is a deposit of gravel and fine sand beneath 4 feet of stripping on the Royer farm in the southeast quarter of section 29. The extent along the valley side was learned in making an excavation for a cistern and noting the material thrown out by groundhogs at a number of places. The depth of the deposit is 6 feet to water level, below which it is not known. The rock percentages and sizes of the material are about the average for the county.

Gravel with a small per cent. of fine sand is found beneath from ½ to 6 feet of surface on the land of J. W. Morrison in the northwest quarter of section 32 (20 N., 2 W.). The extent is known for 300 yards along the valley side of a small tributary to Sugar Creek, and the depth is 9 feet, no bottom being found. The sizes of the material are a little below the average.

Ten or twelve acres are said to be underlain by gravel and sand in the first terrace above the flood plain of Sugar Creek on the J. T. Wild place in the northwest quarter of section 33 (20 N., 2 W.). Post auger holes have been the main tests.

In the north central part of section 34 (21 N., 2 W.), on the property belonging to M. Riley, is a bed of gravel and sand, above ground-water level, which is claimed to underlie 40 acres, as has been learned by post holes and plowing. At the pit, where no bottom has been found, the depth is 18 feet and the stripping from 1 to 3 feet. A section shows (a) stripping, 3 feet; (b) an average size gravel, 4 feet; (c) fine sand, 1½ feet; (d) an average size gravel, 4 feet; (e) fine sand, 2 feet; (f) a material a little below average in size, 6 feet. The rock percentages are 60 limestone, 16 shale, 12 crystallines, 6 sandstone, and 5 chert.

Near where Prairie Creek empties into Sugar Creek, and 1¼ miles east of this place on Sugar Creek, also on Prairie Creek in East Thorntown, a large amount of gravel is obtained from the bars in the creek beds. These are formed by the floods, and give, when sufficiently coarse, a very durable material. The main objection to it is the insufficient amount of clay to aid in packing.

On the land of J. S. Corrie in the southwest quarter of section 36 (20 N., 2 W.), is a bed of gravel in the bluff of Prairie Creek. The extent of this bed, as has been learned by the drying up of crops and post holes, is 4 or 5 acres. A section at the pit shows the following: (a) Stripping, 2 to 4 feet; (b) very coarse gravel and boulders, 6 feet; (c) fine sand, ½ foot; (d) average size gravel, 3½ feet; (e) fine gravel, 1½ feet; (f) average size gravel, 4 feet. The rock percentages are 60 limestone, 16 crystallines, 12 shale, 6 sandstone, and 4 chert.

Rather similar deposits, which are workable, are reported on the Cook and Crouch farms of the southeast quarter of section 26 and the northeast quarter of section 35 (20 N., 2 W.).

In the flood plain of a tributary to Sugar Creek in the southwestern quarter of section 14 (20 N., 2 W.), is a bed of gravel beneath ground-water level, which is sufficient in extent for the setting of a gravel excavator, as has been learned by detailed tests.

In the bluff, where Sugar Creek has made a broad meander to the north, is a large bed of one-third gravel and two-thirds fine sand, on the places of W. Beck and C. Beck in the northwest quarter of section 29 (20 N., 1 W.). This deposit follows the bluff for 300 yards and extends back from 1 to 15 yards, as has been learned by groundhog holes and rough tests. The stripping is from 2 to 4 feet, and depth 6 to 20 feet. Gradations from gravel to fine sand are very frequent. Excepting the fine sand, the material is above the average for size. The roads built and repaired by this material are smooth and durable. The association with fine sand and being ½ mile from the public highway makes this deposit somewhat inavailable.

Other openings into the deposits along Sugar Creek are found on the Foster place in the southeast quarter of section 21, the N. H. Bunten and H. Witt farms in the southeast quarter of section 22, the J. Wells in the southwest quarter of section 23, the J. Richey in the southwest quarter of section 24 (20 N., 1 W.), the Andrew Sheets in the northwest quarter of section 19, and the Ingleman place in the southwest quarter of section 17 (20 N., 1 E.).

The Bunten and Wells deposit is located in a ridge between

Sugar Creek and a tributary. At each end of an area 250 by 100 yards are the pits of the two parties. The intervening area has been tested at various points and is known to be underlain with gravel and sand. At one point the deposit was tested to a depth of 50 feet by driving a pipe, and no bottom to the bed was found. At the pits, a number of lenses of fine sand are exposed, the stripping ranging from 2 to 3 feet. The material varies greatly in size, an average of three samples showing 3 per cent. clay, 13 per cent. fine medium sand, 13 per cent. medium sand, 24 per cent. coarse sand, 19 per cent. roofing pebble, 25 per cent. gravel, and 4 per cent. boulder. The rock percentages are 80 limestone, 13 crystallines, 5 shale, 1 slate, and 1 chert. On the roads this material is durable and gives good satisfaction. A workable and similar quality is found on the Witt farm.

For about 200 yards in the stream bluff on the Richey place, gravel and fine sand have been found to underlie the surface, but the high percentage of fine sand and its frequent alternations with the gravel makes its economical value doubtful. Very careful testing will be necessary before opening it. The gravel, if separated from the fine sand, is a little below the average for the county.

On the Sheets place, a hill, with a surface of 50 by 40 yards, and 15 feet high, is known to be filled with gravel, under about 2½ feet of stripping, as is seen by a number of groundhog diggings about it and pits at either end. The sizes of the material are a little below the average. Another hill, of about equal dimensions, is found 300 yards west. On this, the corn withers away and the plow turns up the gravel. In the flood plain of a small tributary to Sugar Creek on this place, Andrew Sheets has made tests, which show the surface to be underlain with gravel for over 100 yards along the stream.

Tests have been made in the bluffs of Sugar Creek on the Ingleman place that show the gravel to underlie a surface of 100 by 30 yards. The depth of the bed is from 7 to 8 feet to groundwater level, and the stripping 2½ to 6 feet. The sizes of the material are about average.

In the flood plain of a tributary to Sugar Creek on the property belonging to A. Hogshier in the northwest quarter of section

30 (20 N., 1 E.), is a 4-foot bed of gravel beneath 4 feet of stripping and below ground-water level. The material is obtained by pumping out the water and then operating it the same as a deposit above water level. The extent of the bed, as a few general tests have indicated, is 2 or 3 acres. The quality is about the average for the county.

A large portion of the gravel obtained for this part of the civil township of Clinton is taken from the flood deposits, 200 yards south of the Hogshier pit.

On the Brenton and Caldwell farms in the southeast quarter of section 32 (20 N., 1 E.), is a bed of gravel beneath the ground-water level and 3 feet of surface. This bed rests upon a clay bottom, is from 6 to 12 feet deep at the pit, and underlies 2 acres of surface, as tests have shown. The sizes of the material are 8 per cent. clay, 15 per cent. fine medium sand, 20 per cent. medium sand, 30 per cent. coarse sand, 15 per cent. roofing pebble, 11 per cent. gravel, and 1 per cent. boulder; and the rock percentages are 80 limestone, 13 crystallines, 5 shale, 1 chert, and 1 slate. The amount of clay and the unweathered condition greatly aids this material in making a smooth, hard, and, durable road.

Three or four acres are said to be underlain by gravel, beneath ground-water level, on the Mutchler place in the southwest corner of section 13 (20 N., 2 E.). Some of this material that has been taken out is a little above average in size and of very durable quality.

Township 19 North, Ranges 1 and 2 West, and 1 and 2 East.

Small beds of gravel are found beneath the ground-water level on the William Haines place in the south central part of section 13, the J. Hancock in the east central part of section 15, the I. Coupland in the southwest quarter of section 10, the C. A. Berry in the southwest quarter of section 16, and the T. O. Cobb in the southeast corner of section 18 (19 N., 2 E.). The Hancock deposit has 3 or 4 feet of stripping, underlies a tested area of 80 by 15 yards, and has a depth of 10 feet. The rock percentages are 75 limestone, 10 crystallines, 10 shale, 3 chert, and 2 slate; and the sizes of the material are 7 per cent. clay, 25 per cent. fine

medium sand, 30 per cent. medium sand, 20 per cent. coarse sand, 8 per cent. roofing pebble, and 10 per cent. gravel. This is a very fine material for road purposes. A similar material is found in the Coupland farm. The area underlain is 33 1-3 by 15 yards, and the depth is 4 feet.

On the Tucker farm in the north central part of section 6 (19 N., 2 E.), is a carefully tested area of 130 by 15 yards, with an average depth of 12 feet. The sizes of the material are about the average. With the exception of the Mutchler deposit, this is the best quality of gravel found in the civil township of Marion. The roads on which it is used are smooth, hard and durable.

On the W. N. Bohannon and O. Bohannon land in the southeast quarter of section 24 (19 N., 1 E.), is a bed of gravel and fine sand 350 by 35 yards, which has received the following tests: At the north end a location has been thoroughly tested for setting a machine for dipping; 70 yards south gravel has been chained out to a depth of 18 feet, where clay was struck; at the southern end, 80 yards north and 160 yards north, small tile ditches running east and west struck the gravel at about 3 feet from the surface and remained in it for about 7 yards. The gravel obtained is a little below the average for size and quality, having only 2 per cent. of clay. The rock percentages are 75 limestone, 10 crystallines, 10 shale, 3 chert, and 2 slate. Roads built with this material are very slow in packing.

Beneath an old swamp, which has been drained, in the southeast quarter of section 35 (19 N., 1 E.), on the farm belonging to Samuel Heath, is a bed of gravel, beneath ground-water level, which is claimed to have been tested by digging and pipe driving, and to have been found to underlie an area 700 by 15 yards. The average stripping is 3 feet and the average depth is 10 feet. The sizes of the material, excepting the fine sand into which the gravel frequently merges, are about the average.

On the I. C. Adney and Edmund Lovingfaust farms in the northeast quarter of section 29 considerable surface appears to be underlain by gravel. An old pit on the former place was worked down to water level and abandoned, no bottom to the gravel having been found, while on the latter a ditch was in the gravel for about 200 yards. The stripping ranges from 3 to 5 feet and the depth is unknown.

Passing the southeast corner of Lebanon and extending for 2 or 3 miles northeast is an old filled up stream valley, which is known to contain gravel beds at a number of places. One of these, which is on the F. B. Spenser property in the southeast quarter of section 31 (19 N., 1 E.), is known by F. B. Spenser to underlie an area of 400 by 15 yards. At one end of this area a ditch is in the gravel for 6 feet; in the central part, chaining has been done to a depth of 15 feet and no bottom found, and at the other end, a well at the house is in the gravel for 15 feet and no bottom reached. At the pit, the stripping is 3½ feet. The sizes of the material are 1 per cent. clay, 2 per cent. fine medium sand, 3 per cent. medium sand, 18 per cent. coarse sand, 52 per cent. roofing pebble, 20 per cent. gravel, and 4 per cent. boulder; the rock percentages are 78 limestone, 8 shale, 10 crystallines, 2 slate, and 2 chert, and the amount of weathering is nothing. With exception of not having sufficient clay to pack well, this will rank as the best road material in the county.

One mile north and one-quarter of a mile east of this deposit is the Miller deposit, in the same old valley. Here, the depth is 7 feet, the stripping 9 feet, and the extent unknown. The sizes of the material are above the average and little oxidized.

Beneath the flood plain and channel of Prairie Creek are gravel beds on the property of D. J. Partner in northwestern Lebanon, J. Kersey in the northeast quarter of section 26, and on the Partner farm in the central part of section 23 (19 N., 1 W.).

The D. J. Partner deposit underlies an area of 150 by 4 yards, has a depth of 10 feet at the pit, and a stripping of 4 feet. About one-half of the material ranges between a fine sand and fine medium sand. A sample gives a gravel below the average in size and with a rock composition of 85 per cent. limestone, 8 per cent. crystallines, 4 per cent. shale, and 3 per cent. chert.

The Kersey deposit was found, in dredging out the stream, to extend 100 yards and then run into clay. The width and depth were not determined. The material thrown out is too fine for road purposes.

In the bluff of Prairie Creek in the northwest quarter of section 9 (19 N., 1 W.), on the land of J. Stahley, is a bed of gravel beneath from 5 to 8 feet of stripping, with a depth ranging be-

tween 7 and 10 feet, and an unknown extent. A section, at the pit, shows (a) stripping, 6 feet; (b) gravel a little below the average size, 2 feet; (c) average size gravel, 3 feet; (d) fine sand, 2 feet; (e) average size gravel, 5 feet. Other locations are reported on this farm.

In the northeast quarter of section 11 (19 N., 1 W.), on the property belonging to J. Witt, is a bed of gravel beneath from 2½ to 4 feet of stripping, with a size a little below the average. A similar deposit is found in the northwest quarter of the same section with a known extent of 30 by 30 yards, and a depth of 12 feet. The rock composition of both is about the average.

A little better than an average size of gravel is found underlying an area of 90 by 18 yards beneath ground-water level on the Sweet farm in the southwest quarter of section 19 (19 N., 1 W.). The depth is 12 feet and the stripping from 3 to 6 feet.

A gravel of similar size is found, beneath the ground-water level, in the south central part of section 19 and the north central part of section 30 (19 N., 1 W.), on the place of Carl Bowman. An area of 300 by 15 yards has been tested and is known to contain several pockets, one of which is sufficiently large for the setting of a gravel excavator. Excepting the fine sand, which occurs as lenses in the gravel, the size of the material and the rock composition are about average. This material has been used on the roads for 3 miles west, 4 miles south, and 3 miles east, and has given good satisfaction.

In a kame on the farms of L. Taylor and D. Craft in the west central part of section 15 (19 N., 2 W.), underlying an area of 200 by 30 yards, is a deposit of gravel, which frequently merges into clay and fine sand. Two pits are found in this deposit, which show a depth ranging between 16 and 25 feet, and a stripping between 2 and 6 feet. For rock composition the material is about the average, but low in size.

In the southeast quarter of section 10 (19 N., 2 W.), on the place of Addison Orear, is a bed of gravel and fine sand in a stream bluff which shows at the pit a depth of from 15 to 34 feet and a stripping ranging between 1 and 4 feet. An area of 150 by 3 yards has been tested and is known to be underlain, but a much larger extent is almost certain. The average of 3 sam-

ples gives about the average sizes for the county, and the rock percentages are also average. Very pronounced gradations of the gravel into fine sand are quite noticeable, and the fine sand and gravel become so intermingled that it is necessary to use a screen before the material is suitable for road use.

On the property belonging to L. W. Beesley, in the west-central part of section 4 (19 N., 2 W.), is a bed of gravel in the bluff of a tributary to Sugar Creek. It is covered by 3½ feet of surface, has a depth ranging between 6 and 10 feet, and a possible extent of 300 yards along the bluff, as was learned by the bottom of the excavation for a cistern, which is 300 yards from the pit, being in the gravel. Several other excavations were made along the bluff between these points, which also showed gravel. It is, however, very possible that it will be with some difficulty that further locations will be found, because of the frequency of the abrupt grading into fine sand. The sizes of the material and general quality are about average.

A poorly stratified bed of gravel is found on the Edmund Beesley property, in the northwest corner of section 18 (19 N., 2 W.). This bed underlies an area of 100 by 20 yards, has a depth ranging between 6 and 30 feet and a stripping of 1½ to 6 feet. The rock percentages are about average, and the sizes of the material are a little above. About 1,000 cubic yards, at a cost of 20 cents each, are used in the annual repairing and building of the roads for 3 miles west, 4 miles south, and 3 miles east. These roads, where properly attended to, are smooth, hard and durable.

Township 18 and Part of 17 North, Ranges 1 and 2 West, and 1 and 2 East.

Along Walnut Creek and beneath the ground-water level in the southeast corner of section 5 and the northeast corner of section 8 on the farms of J. Beck, W. Hunt and R. Gordon is a bed of gravel which by general tests seems to have a length of 450 yards and a width of 20 yards. On its northeastern portion three settings have been located for a gravel excavator, which will yield about 15,000 cubic yards of material. Further detailed tests have not been made. The depth ranges between 20 and 25 feet and the

stripping from 4 to 6 feet. The sizes of the material are about the average for the county. The roads built with this material are hard, smooth, durable and less dusty than the average.

In the southwest quarter of section 7 (18 N., 2 W.) the bottom of a ditch which crosses the G. Davis place is said to be in gravel for ½ of a mile.

A setting for a gravel excavator is reported to be present on the J. Coons place in the west-central part of section 17 (18 N., 2 W.). The depth of the deposit is 18 feet.

Along Raccoon Creek tests have indicated locations for setting a gravel excavator on the Jones farm in the northeast quarter of section 26 (18 N., 2 W.), and the Holsteter, near the central part of section 27 (18 N., 2 W.). Along the same stream on the D. Duncan farm, in the northeast quarter of section 31 (18 N., 2 W.), gravel of a rather poor quality underlies the surface; a pipe test on the Howard farm, in the northwest quarter of section 26 (18 N., 2 W.), showed 15 feet of gravel, and tests on the Caldwell and Lewis places, in the southeast quarter of section 28 (18 N., 2 W.), showed the surface to be underlain by gravel. Some very scattered tests are said to have indicated a thickness of 12 feet of gravel at several points, in an area of two acres, on the McLachlin property, in the southeast quarter of section 13 (18 N., 2 W.).

A number of fair sized deposits are found in the bluffs of the North and South Forks of Eel River. Among these is a workable deposit on the Osborne heirs' land, in the north-central part of section 12 (17 N., 2 W.). The material is average in rock composition and size.

Along the bluff of the North Fork of Eel River, on the property belonging to T. Kibby, in the southeast quarter of section 31 (18 N., 1 W.), is a bed of gravel beneath from 2 to 5 feet of surface extending for 300 yards. This extent has been determined by pit openings and groundhog diggings. The depth is 10 feet, the rock composition is about the average for the county, and the sizes of the material, excepting fine sand into which the gravel frequently merges, are a little below.

On the Budd and Morrison places, in the southwest quarter of section 15 (18 N., 1 W.), are some beds below ground-water

level which contain gravel with an average rock composition, but the sizes are 6 per cent. clay, 30 per cent. fine medium sand, 28 per cent. medium sand, 25 per cent. coarse sand, 5 per cent. roofing pebble, and 6 per cent. gravel, and these are commingled with a fine sand, so that the material is very poor for road purposes.

In a kame which stands out very conspicuously, being 25 feet above the adjacent country, in the southwest quarter of section 7 (17 N., 1 W.), on the farms of Mrs. J. C. Gibson and W. L. Dale, is a bed of gravel and fine sand, mainly unstratified, beneath 3 feet of stripping and with a depth varying between 12 and 20 feet. The amount of surface underlain is 350 by 15 yards, and the sizes of the material and the rock percentages are about the average. Although somewhat oxidized, this material makes a smooth, durable, and very satisfactory road.

In a hill in the east-central part of section 5 (17 N., 1 W.), on the land of D. W. Highland, is about 1,000 square yards underlain with 6 feet of gravel and with 3 feet of stripping. The sizes of the material are above the average and the material is of a very good quality.

A poorly stratified bed of gravel is found in a kame on the J. Kernodel place in the northeast quarter of section 33 (18 N., 1 W.). The thickness of this bed ranges between 5 and 20 feet above ground-water level and is more than 2 feet below. The area underlain, as rough tests have indicated, is 2 or 3 acres. The sizes of the material are about the average and the rock percentages are 85 limestone, 9 crystallines, 5 chert, and 1 shale. For road purposes this is a good material.

On the W. Highland place, in the northwest quarter of section 4 (17 N., 1 W.), is a bed of gravel beneath ground-water level underlying an area of 200 by 100 yards. This area has been determined by a bank pit being worked down to water level and then abandoned without reaching the bottom.

Located in a low morainic hill in the southwest quarter of section 14 (18 N., 1 W.), on the land of J. B. Cunningham, is a bed of gravel beneath ground-water level underlying a tested area of 150 by 20 yards, with a stripping of 7 feet and an unknown depth. The sizes of the material are somewhat below the average.

Besides the morainic deposits mentioned in the southern half of the civil township, Harrison, there are, without doubt, a number of others in the many kames of this region.

On the T. Acton place, near the center of section 6 (17 N., 1 E.), gravel of a fair quality has been found beneath ground-water level, but the dimensions of the bed are not known. A workable bed beneath ground-water level is also located on the land of M. Wiley, in the northeast quarter of section 18 (18 N., 1 E.). It lies beneath 3 feet of surface, and has a thickness of 10 feet. The sizes of the material are 4 per cent. clay, 20 per cent. fine medium sand, 20 per cent. medium sand, 26 per cent. coarse sand, 25 per cent. roofing pebble, and 3 per cent. gravel.

A material a little below average for size is found in the northeast corner of section 27 (18 N., 1 E.), on the Smith farm. There are 3 pits on this place from which it is said the water was pumped out and the bed worked to a depth of 8 feet below ground-water level without finding any bottom. By taking the bottom of these pits together with the space intervening between them, we get an area of 200 by 20 yards that is underlain with gravel. This would be a good place to make tests for chaining or dipping, since it lies in a region that contains no deposits of economic importance.

In the flood plain of a stream on the property of L. Cheney, in the east-central part of section 10 (17 N., 1 E.), two locations have been found for setting a gravel excavator. The stripping over these deposits ranges between 3 and 4 feet, and the size of the material is a little below the average. Resting upon a clay bottom and with a depth varying between 7 and 20 feet is a bed of gravel with a possible extent of 200 by 50 yards. The evidence for this extent is as follows: When the water is pumped out of the pit, which is in the central part of the area and is about 125 by 40 feet, wells at either end of it immediately become dry, thus showing either a gravel or coarse sand connection.

At 40 cents per cubic yard this material is used in the building and repairing of the roads for 4 miles west, 2½ miles north, 1 mile east, and 1½ miles south, and gives good satisfaction. The greatest difficulty with this gravel, and also the gravel of the greater part of this county, is that it does not contain enough clay to pack readily.

One acre is underlain by a bed of gravel above ground-water level on the L. D. Pavey place, in the northeast quarter of section 5 (17 N., 2 E.). The thickness is from 6 to 7 feet and the stripping ranges between 2 and 3 feet. The sizes of the material are splendid, being 6 per cent. clay, 10 per cent. fine medium sand, 5 per cent. medium sand, 13 per cent. coarse sand, 40 per cent. roofing pebble, 24 per cent. gravel, and 2 per cent. boulder. The roads built and repaired with this material are durable and give good satisfaction.

Some very good deposits, both in size and quality, are found in the bluffs and flood plains of Eagle Creek. Among some of the bluff openings that have been made are those on the places of B. Bender, in the southeast quarter of section 2; J. Byers and J. Beeler, in the southeast quarter of section 35; P. Moore, in the northwest quarter of section 26 (18 N., 2 E.); H. Nichols, in the northwest quarter of section 11, and J. New, in the northwest quarter of section 11 (18 N., 2 W.). All of these deposits are above the ground-water level.

The Bender deposit is kown to underlie an area of 70 by 15 yards, to have an average depth of 15 feet, and a stripping of 2½ feet. A section at the pit shows (a) stripping, 2½ feet; (b) gravel, a little above average in size and with lenses of fine sand, 2½ feet; (c) a very fine gravel and fine sand grading into one another, 2½ feet; (d) crystalline boulders, ranging from 2 to 8 inches in diameter, 1 foot; (e) gravel a little above average for size, 9 feet. The amount of weathering is below the average for a bed above ground-water level, and the durability for road use is above.

On the Byers and Beeler places the deposit has an extent of 60 by 20 yards, a depth of 22 feet and a stripping of 2½ feet. The sizes of the material are a little below the average.

Besides the two deposits mentioned in the preceding paragraphs there are numerous others in this neighborhood. Many of the cellars and dug wells of Zionsville are in the gravel, and at various places, both north and south of this town, material is known to be present in the bluffs, but has not been opened. In addition to these unopened bluff deposits, excavations of various kinds have shown that great quantities of gravel exist beneath the flood plains.

Creek gravel, which is deposited in bars on the lower flood plain and in the creek channel at times of flood, furnishes one of the main sources of supply for this vicinity.

The bed on the Moore farm is known to underlie the bluff for about 200 yards, with a stripping of about 3 feet and a thickness of 15 feet. The sizes of the material would be about average if the fine sand, which composes over half of the deposit, were screened off. The flood plain on this same farm for 2 or 3 acres is known by rough tests to be largely underlain by gravel and fine sand, but the depth has not been determined.

On the Nichols and New places a deposit of gravel and fine sand extends for a couple of hundred yards along the bluff, having a depth ranging between 10 and 22 feet and a stripping between 1 and 4 feet. Many lenses of fine sand and gradations into fine sand are present. A section shows (a) stripping, 1½ feet; (b) average size gravel, 2 feet; (c) fine sand, 2 feet; (d) gravel above the average for size, 3 feet; (e) average size gravel with large lenses of fine sand, 2 feet; (f) gravel above the average for size, 5 feet. The rock percentages are 87 limestone, 9 crystallines, 3 shale, and 1 chert. About 1,500 cubic yards, at a cost of 15 cents each, are used in the annual repairing and building of roads. These roads, where kept in proper repair, are smooth and giving good satisfaction.

With 8 feet of gravel above and 8 feet below ground-water level, is a workable bed of gravel on the L. Kendall place, in the southeast quarter of section 16 (18 N., 2 E.). The stripping is 3 feet, and the sizes of the material, excepting fine sand, which makes up a third of the deposit, are about average. The rock percentages are 85 limestone, 10 crystallines, 3 shale, 1 chert, and 1 slate.

A similar material is found underlying about 2 acres, as plowing and post holes show, on the Susan Hull property, in the northwest quarter of section 21 (18 N., 2 E.). This deposit is 7 feet deep and is covered by 2½ feet of surface.

An extent of 50 by 15 yards of gravel beneath ground-water level is known to be present on the William Groover property, in the northeast quarter of section 24 (18 N., 1 E.). The stripping is 3 feet and the depth has not been determined. The size of the material is considerably below the average.

On the W. H. Witt land, in the southwest quarter of section 13 (18 N., 1 E.), is a small bed of gravel beneath 2½ feet of stripping.

In concluding the mention of the Boone County deposits the writer will suggest that for areas without gravel and where it is necessary to haul it for several miles, as in the central part of the civil township of Worth, the northwest and central parts of Perry, the central and eastern parts of Jefferson, the southern part of Clinton, and the northwestern part of Marion, that careful investigation be made as to the durability of the better road metal, limestone, and the cost of obtaining the same on the nearest railway switch.

SECTION IX.

THE ROADS AND ROAD MATERIALS OF A PORTION OF WESTERN INDIANA.

EMBRACING THE COUNTIES OF TIPPECANOE, WARREN, FOUNTAIN, MONTGOMERY, VERMILLION, PARKE, VIGO, CLAY, SULLIVAN AND KNOX.

BY J. T. SCOVELL.

The counties above mentioned whose road materials are treated in this section are in the valley of the Wabash and, excepting Clay and Montgomery, they border on that river. The Wabash rises in the central-western part of Ohio and flows northwesterly to Huntington, in northeastern Indiana, thence southwesterly to the region of Covington, in Fountain County, thence southerly into the Ohio River. From its source to Huntington the river occupies a recent or post-glacial channel, with banks and bed of drift materials, having no bluffs, terraces nor flood plains. Below Huntington the river follows the old Erie-Wabash channel, that formerly carried the surplus waters of Lake Maumee.

For much the greater part of its course this old channel follows an ancient preglacial channel that has been partially filled with glacial drift. In the northeastern part of Fountain County the river flows for a few miles in a recent channel with bed and banks of rock. The same is true at Delphi, in Carroll County, at Logansport, and at other places. It is supposed that some obstruction, probably masses of glacial drift, forced the old Erie-Wabash to take shorter courses and cut new channels across the necks of curves in the ancient channel. From Attica, in Fountain County, southward there is no doubt about the preglacial channel. From Huntington the valley of the Wabash, including flood plains and terraces, is one to three miles wide, spreading out in some places, as in Vigo County, to a width of five or six miles. The flood plain is from a half mile to two miles wide, reaching

in some places a width of three or four miles. This flood plain rises from 8 to 20 feet above low water in the river, and is usually composed of silt, clay and fine sand, but sometimes the great body of the plain is heavy gravel covered with a thin layer of silt, as in the southern part of Vigo County. In general the fine silts characteristic of the flood plain rest on the masses of sand and gravel that form the bed of the river.

The river zigzags across the flood plain from bluff to terrace and terrace to bluff, cutting the plain up into sections of different lengths. The terraces rise from 15 to 75 feet above low water in the river, and are generally composed of sand and gravel. Sometimes what seems to be a terrace is really a rock shelf, sandstone, limestone or shale. The old river that formed the terraces zigzagged across the ancient channel from bluff to bluff, so that the terrace is cut up into sections. At Williamsport, in Warren County, the river flows along the bluff on the west. At Portland, in Fountain County, it flows along the bluff on the east. In the southern part of Warren County the river, or its flood plain, has again shifted to the bluff on the west, and the terrace is on the east. Below Covington the river flows near the east bluff, and the terrace is on the west. Below Newport the river has again crossed to near the west bluff and the terrace is on the east. At Lyford, in the southern part of Parke County, the river is near the bluff on the east and the terrace is on the west. Through Vigo County the river is nearer the west bluff and the terrace is on the east. In the northern part of Sullivan County the river flows near the bluff on the east and the terrace is on the west.

The terraces at Cayuga, in Vermillion County; at Montezuma, in Parke County, and at Terre Haute, in Vigo County, seem to occupy basins or wide places in the ancient channel. Along the bluff in the northern part of Parke County, at several points in Vigo County, and in the northern part of Sullivan County, there are sand dunes and great deposits of wind-blown sand. These dunes seem to indicate that the ancient channel must have been occupied for a long period of time by a lake or a sluggish stream. Deep wells at Lafayette, Attica and Terre Haute show that there are at least 100 feet of sand and gravel between low water in the river and the bed of the ancient channel. Deep wells in the

terrace at Terre Haute and tests made for gravel show in general rather coarse gravel at or near the surface, while the lower portions are of sand or much finer gravel. This arrangement suggests a delta formation. It is interesting to note that the sand and gravel in the terraces are stratified but not well assorted, fine sand and coarse gravel stones occurring together, often associated with large boulders and sometimes with angular fragments of coal and shale and masses of boulder clay.

At many places in Warren, Tippecanoe, Montgomery, Clay and other counties old channels and basins have been partially filled with sand and gravel, and these materials then covered with prairie soil or with boulder clay of varying thickness. In Jordan Township, Warren County, on sections 7, 8, 17 and 18 (22 N., 10 W.), there is a deposit of "water gravel" having an area of at least 1,000 acres. The gravel is from 10 to 15 feet thick and is covered with from 3 to 6 feet of prairie soil and clay. Such gravel deposits are usually filled with water. In the northern part of Clay County there is a preglacial channel that has been partly filled with sand and gravel, and these covered with boulder clay from 5 to 30 feet deep. In a mine at Fontanet, Vigo County, they found a little stream bed with sand, gravel and boulders covered 100 feet deep with boulder clay.

In Tippecanoe, Fountain and Montgomery counties there are irregular gravel ridges that seem to be eskers, and hundreds of little mounds or hills of sand and gravel that are perhaps kames. Shawnee Mound, in southwestern Tippecanoe County, is thought to be a kame, and a long gravel ridge north of Romney, in the same county, is a good illustration of an esker. But many gravel deposits that look like kames when investigated are found to extend far below water level, filling some old channel or basin. Thus we may find a gravel deposit whose base and body is subterranean or water gravel with a summit of kame gravel. About Lafayette and Attica these kame-like deposits cover the face of the bluff and blend with the terrace so as to greatly obscure the features of each.

There are also quantities of good gravel in the streams. This gravel may come from the terraces, may come from disintegrating boulder clay, but perhaps more largely from little pockets of gravel

distributed irregularly through the boulder clay. In Tippecanoe and Warren counties gravel and boulder clay are frequently interstratified, the clay being sometimes the more abundant and sometimes the gravel forming the thicker beds. These masses of sand and gravel are supposed to have been deposited by the glacier, but in general the forms have been largely determined by running water. As the glacier moved slowly southward, the summer floods, the streams from the wasting ice, filled many of the old channels and basins with sand and gravel, much as a delta is formed, the finer materials in general below, the coarser above, but the materials in the upper portions are seldom well assorted. The advancing ice gradually covered these deposits, protecting them somewhat from erosive agencies. As the glacier retreated the materials of the drift covered the deposits of gravel. In some cases the summer floods carried away the drift and often large quantities of the gravel. In other cases the sand and gravel remained undisturbed under its cover of drift materials. Recent drainage channels, cutting down into the drift, occasionally disclose some of these hidden masses, or it may be that a well or a mining shaft reveals the presence of these buried gravels.

The interstratification of clay and gravel may perhaps be explained by a second advance of the ice, or by alternate advances and retreats of the ice for a few miles, on account of changing climatic conditions. Eskers, kames and similar forms of drift are possibly divisible into two classes; first, those that stand on boulder clay and are probably the products of the last advance of the ice, perhaps formed while the glacier was building the Shelbyville moraine; second, those that stand in old channels or basins, seeming to be products of the first advance of the ice, modified in form by later ice, and perhaps surrounded with boulder clay, but not covered by it. The sand and gravel of the region under discussion is therefore seen to be abundant and to exist under a great variety of forms and circumstances.

In general the sands and gravels of this region are of glacial origin. They are for the most part derived from broken-down granite, sandstone and limestone rocks. The sand, especially the finer sands, are nearly pure quartz. This quartz may have been derived from disintegrating sandstones or granitic rocks, or from

geodes of limestone rocks. In the coarser sands and finer gravels, diorite, felsite, granitic and limestone grains occur, and in the coarser gravels they make up the bulk of the mass. Fully one-half of the quartz in the coarser gravel is derived from geodes. A large per cent., often as much as 25 per cent. to 35 per cent., of the pebbles in coarse gravel are of limestone. These limestones may be solid and of good quality and may help cement the mass together, but they can not compare with the granites in capacity to resist a crushing force.

Almost everything called gravel is used for road building. In general bank run material contains too much sand for first-class road metal. In some places rock has been used in road building, but there are no profitable quarries in the region covered in this report.

TIPPECANOE COUNTY.

Area in square miles	488
Population in 1900	38,659
Miles of public roads	825
Miles of improved roads	400
Percentage of roads improved	48.4
Miles improved with gravel	400
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$850
Total original cost of improved roads	$340,500
Annual cost of repairs per mile on gravel roads 5 years old	$50
First improved roads built	1868
Proportion of improved roads built since 1895 (per cent.)	5
Satisfaction of farmers with investment in improved roads	Good
Authority	H. H. Cheney, County Auditor

Tippecanoe County is in the western central part of the State. It is bounded on the north by Carroll and White counties, on the west by Benton, Warren and Fountain counties, on the south by Montgomery County, and on the east by Clinton and Carroll counties. The county comprises townships 21, 22, 23 and 24 north, in ranges 3, 4, 5 and half of 6 west of the second meridian.

The Wabash River flows across the county and its valley is the dominant feature in the topography of its area. The river enters the county at the northeast corner and flows southwesterly to near the center, then westerly to within about two miles of the

west line of the county, thence southwesterly, crossing the county line about ten and a half miles north of the southwest corner. The surface of the county for the most part slopes toward the Wabash, and the smaller streams of the county all flow into that river.

Tippecanoe River enters the county about three and a half miles west of the northeast corner and flows into the Wabash after a course of about six miles in the county. Other streams from the north are Burnett's Creek and its branches, Big Indian Creek and its tributary, Little Indian Creek, and Little Pine Creek, which flows into Warren County. From the southeast and south the chief tributaries are Sugar and Buck creeks, which rise in Carroll County. Wildcat Creek and its branches drains the southeastern part of the county, Wea Creek drains the central southern part, and Flint Creek drains several sections into the Wabash near the west county line.

The elevation of the Wabash at Lafayette is about 500 feet, and the bluffs about Lafayette rise about 230 feet above the river. Probably few if any points in the county rise more than 800 feet above tide.

Sand and gravel are abundant in Tippecanoe County. There are immense quantities of sand and gravel in the banks and bed of the Wabash River and great quantities along the Wildcat and Wea creeks in their lower courses. In the southern portion of the county there are immense deposits of esker gravel. There is also considerable stream gravel and some morainic gravel. In addition there are some gravel deposits of unknown extent buried under thick beds of clay.

Tippecanoe Township.

In Tippecanoe Township, in the northeastern part of the county, there is considerable gravel in the second bottoms and bluffs of the Wabash and Tippecanoe rivers. Tyler Hill, on section 3 (24 N., 3 W.), is a gravel deposit in the bank of the Wabash. Leffler Hill, on the southeast quarter of section 5, is a gravel deposit in the bank of the Tippecanoe, and Hog Point Hill, in the north half of section 9 is also a gravel deposit of considerable extent. The Booth gravel pit, on the northwest of the southeast of section 9, is perhaps in the Hog Point Hill deposit. The gravel in these localities is of good quality. There are a few boulders

and 30 to 40 per cent. of sand, but bank run material makes good roads. No definite idea could be gained of the area of these deposits except that they are large, many acres in extent. The covering of soil or clay is generally very thin, seldom more than 12 to 30 inches, so that the gravel is easily accessible.

The gravel at Hog Point Hill is from 20 to 30 feet thick, resting on heavy beds of blue clay. I found no place in this region where the gravel deposits reached water level. They appear to be bluff deposits. The Skigley gravel pit, on the east half of the northeast quarter of section 8 (24 N., 3 W.), is in a deposit of at least five or six acres, and there is a face of about 20 feet exposed. Nothing definite is known about the depth. The soil covering is very thin, being only a few inches. The gravel is of good quality with a few boulders and considerable sand intermingled. There is some cemented gravel in the bank, but it does not occur in large masses, so it does not seriously interfere with the working of the pit.

The Sterrett gravel pit, on the south part of section 7; the Smith pit, on the northeast quarter of 7, and a pit in the southwest quarter of 5 (24 N., 3 W.), each furnishes good gravel. In general there are only 12 to 15 inches of soil over the gravel. Nothing definite is known as to the area of these deposits, but there are doubtless several acres in each. There are only 10 to 15 feet of gravel exposed in these pits, but the deposits are claimed to be at least 20 to 30 feet thick.

In the 15th Annual Report of the Indiana Department of Geology Prof. Gorby gives sections of a large number of wells. Some of these sections give information in regard to the distribution of gravel in this region as follows: A well at the residence of Mr. John Gross, on the southwest quarter of section 4 (24 N., 3 W.), near Leffler's Hill, shows:

Section of Gross Well.

		Feet.
1.	Soil	6
2.	Gravel	40
3.	Gray clay	10
4.	Gravel	10
	Water at	66

About the level of the water in the Tippecanoe River.

A section of M. L. Thomas's well, on Moats Creek, northeast of the northwest of section 8 (24 N., 3 W.), not far from the Sterrett and Smith gravel pits, shows:

Section of Thomas Well.

		Feet.
1.	Soil and clay	4
2.	Gravel and sand	20
3.	Hardpan	20
4.	Sand and gravel	25
5.	Gray clay	2
	Total	71

The section of Newton Smith's well, on the south line of section 6 (24 N., 3 W.), near the Smith gravel pit, shows:

Section of N. Smith's Well.

		Feet.
1.	Soil	2
2.	Sand	28
3.	Blue clay	50
4.	Coarse gravel	5
	Total to water	85

Mr. Smith says it is common to find water in the gravel below the clay. These gravel deposits are exposed in the bluffs of streams in some cases clearly resting on beds of clay. The well sections indicate that sand and gravel are somewhat widely distributed in this region; that the deposits are from 20 to 40 feet thick, resting on thick beds of clay or hardpan, and that below the clay there are also extensive beds of gravel.

The town of Battle Ground is located on section 23 (24 N., 4 W.). It stands on a terrace of clay, sand and gravel. The latter seems to be abundant, yet only a few pits have been opened. The Fisher pit, on lot 3 of Burnett's reserve, and others on lots 1 and 2 of the reserve, are just east of town. The gravel is of good quality but contains considerable sand. N. Klossen has a pit on the southwest quarter of section 27 (24 N., 4 W.), just southwest of town. It furnishes good road material. A section of J. M. Hicks' well at Battle Ground, as given by Prof. S. S. Gorby, shows:

Section of Hicks' Well.

		Feet.
1.	Soil	3
2.	Hardpan	3
3.	Gravel and sand	73
	Total	79

A section of J. P. Clute's well shows:

Section of Clute's Well.

		Feet.
1	Soil and clay	4
2.	Coarse gravel	25
3.	Sand	30
4.	Blue clay	1
	Total	60

A section of the bluff of Burnett's Creek, north of Battle Ground, as given by Prof. Gorby, shows:

Section of Bluff of Burnett's Creek.

		Feet.
1.	Soil and yellow clay	10
2.	Fine sand	30
3.	Blue clay	50
	Total	90

Another section of the same bluff shows:

		Feet.
1.	Yellow clay	40
2.	Gravel	50
	Total	90

The section of John Livingstone's well, on the northeast of the northeast of section 28 (24 N., 4 W.), about two miles west of Battle Ground, shows:

Section of Livingstone Well.

		Feet.
1.	Soil and yellow clay	30
2.	Dry sand, fine	20
3.	Blue clay	30
4.	Cemented gravel	2
5.	Loose gravel	13
	Total to water	95

The section of James Bryant's well, on the west half of the northeast quarter of section 29, about three miles west of Battle Ground, shows:

Section of James Bryant Well.

		Feet.
1.	Soil and yellow clay	4
2.	Blue clay	50
3.	Dry sand	20
4.	Coarse gravel	2
	Total to water	76

There is a good gravel pit on Mr. Bryant's place. Mr. A. P. Catherwood, on the east half of the southwest quarter of section 29 (24 N., 4 W.), also has an abundance of good gravel. There are about 15 feet of gravel exposed in the pit, with not much sand. P. G. Smith, in the east half of the northeast quarter of section 9, has several acres of good gravel. Material from this deposit was used in making the Brown gravel road along the east line of sections 4, 9 and 16 (24 N., 4 W.). Gravel is found at several places in the banks and bed of Burnett's Creek, which drains the western portion of Tippecanoe Township.

Wabash Township.

Along the river in the edge of the terrace on sections 8, 17, 18 and 19 (23 N., 4 W.), there is an abundance of sand and gravel. Nothing very definite is known as to the extent or depth of the deposit, but it is supposed to be several hundred acres in area, and from 50 to 75 feet below low water in the river. The Catherwood pit, on section 19, yields large quantities of excellent sand and gravel. Occasionally great masses of cemented material occur. The Big Four Railway and the Lake Erie Railway have extensive gravel pits on sections 30 (23 N., 4 W.), and 25 (23 N., 5 W.), just south of the Purdue University grounds. Great quantities have been taken out for the use of the railways, as well as for shipment. These pits furnish good road material.

The Pierce gravel pit, on the northwest quarter of section 36 (24 N., 5 W.), is in a deposit of four or five acres, which shows soil and clay 4 to 6 feet and sand and gravel 8 to 10 feet, to water. This pit furnished gravel for the Lyman gravel road and

others in its neighborhood. In the northern portion of the township there is very little gravel. I could not learn of any workable pits.

Miller's pit, on the southwest of the northeast of section 3, and Gaylord's pit, on the southeast of the northwest of 3 (24 N., 5 W.), are in a deposit of unknown depth and area. The section exposed is:

	Feet.
1. Soil and clay	2 to 3
2. Sand and gravel	5 to 6

to water. With a scoop in the Miller pit they took out gravel to a depth of 34 feet below water level, without reaching the bottom of the deposit. This gravel is in the valley of Indian Creek and is thought to be several acres in extent. The material is rather fine, containing about as much sand as gravel, but it is considered good road material, and has been used in improving most of the roads in the central portion of the township. There is some gravel along the streams in the north and in the southern portion. Bole's pit, Kidwell's pit, and Cole's pit may be mentioned, but they are not considered of much importance.

There is thought to be an abundance of gravel in the southwestern part of the township, but little has been developed.

Shelby Township.

The northern portion of this township has no good gravel pits. The material for improving the roads of this portion of the township came largely from the Judd pit in White County. The gravel roads in the central portion of the township were made with gravel from the Gaylord and Miller pits in Wabash Township. In the western central portion several deep wells show:

	Feet.
1. Soil and clay	20 to 25
2. Sand and gravel	20 to 80

It is quite possible that in some localities the sand and gravel may be so near the surface that it might be taken out with profit, but no such localities have been discovered, unless Gaylord's

and Jordan's pits, and other deposits along Indian Creek, are such localities uncovered by the work of running water.

In the southern portion of the township in the river terraces and along the bluffs of Indian Creek there is an abundance of gravel. The Indian Hill pit is in the bank of Indian Creek on the north half of the northwest quarter of section 17 (23 N., 5 W.). As opened the pit shows:

	Feet.
1. Soil and clay	2 to 4
2. Gravel	18 to 20

It is called good road material. Large quantities of gravel are shipped from this pit to points in the northeastern portion of Warren County.

Washington Township.

This township, lying in the northeastern part of the county, has plenty of gravel. In general along the river bluffs there is sand and gravel and boulder clay. Peter Ritterath has a good gravel pit on the northeast quarter of section 31 (24 N., 3 W.). It is several acres in extent and shows soil and clay one to three feet, gravel exposed 15 to 20 feet. There is considerable fine sand in the deposit, but it is called good road material. George Frida has an abundance of gravel on the northeast quarter of section 20 (24 N., 3 W.). It is of good quality, perhaps a little coarser than that in Ritterath's pit, and makes a good road.

On the southeast of the northeast of section 16 there is a large body of good road material, containing some fine sand and a few boulders. On the northwest of the northeast of section 15 there is a large deposit of gravel and sand. There is but little very fine sand and but few boulders. This deposit consists of several acres and is perhaps 20 feet thick to the level of a little creek. The section exposed contained a large per cent. of coarse gravel. The Culp gravel pit, in the northeast of the southwest of section 11, yields an abundance of good road material. There is also some good gravel along Sugar Creek.

Buck Creek Station is on the northeast corner of the northwest quarter of section 33 (24 N., 3 W.). A section of a well, given by Prof. Gorby, shows:

Section of Well at Buck Creek Station.

		Feet.
1.	Soil and yellow clay	5
2.	Blue clay	15
3.	Fine yellow sand	30
	Total	50

Another section by Prof. Gorby, about one mile west of Buck Creek, shows:

Section One Mile West of Buck Creek.

		Feet.
1.	Soil and yellow clay	6
2.	Gravel and sand	49
3.	Blue clay	5
	Total	60

East of Buck Creek are the Buck Creek bottoms, a flat, prairie like country with deep black soil. Wells in this region, according to J. C. Eckhart, show:

		Feet.
1.	Black soil about	6
2.	Quicksand about	20
3.	Blue clay	6
4.	Sand or gravel	10+

Perry Township.

This township lies south of Washington, and corresponds to township 23 north, range 3 west. The North and Middle branches of Wildcat Creek flow across the township from the east, uniting in section 18 near the western boundary. The surface along these streams is much broken, exposing many deposits of gravel, some of considerable size.

Blinkenstaff's pit, on the northeast of the southwest of section 11, is in a deposit of 5 or 6 acres in extent. An exposure in the bank of a little creek shows soil and clay 1 to 3 feet and good gravel 18 feet. There are small deposits at other points along the North branch of Wildcat Creek. On George Griffith's place, in section 7, there is a large deposit of gravel extending on to other farms. It is a good material and is perhaps the largest deposit in the township.

On the northwest quarter of section 21 Owen McCormick has 8 or 10 acres of gravel in the bluff of the Middle branch of Wildcat Creek. Where it outcrops in the bluff there is but little stripping, but back in the hill there is 10 to 15 feet of soil and clay over the gravel, so that there are probably not more than 2 or 3 acres that can be worked at a profit. There are only about 10 feet of gravel exposed in the pit, but it is thought to extend much deeper, a thickness of 25 to 30 feet being claimed. It appears to be of very good quality. Frank Eagleshoff has also a deposit of good gravel on the northwest quarter of section 20.

Wallace Patton has an abundance of gravel on the south part of section 22, but it is under 4 to 6 feet of soil and clay. F. M. Widner, Samuel Weaver and Samuel Payne have large quantities of gravel on section 28, with only two or three feet of stripping above, and so situated in the creek bluff as to be easily accessible. The gravel is generally good, with some cemented material and some fine sand. Wells and exposures in pits and bluffs show this deposit to be at least 15 to 20 feet thick, apparently resting on blue clay.

Ben De Long has gravel on the southwest quarter of section 22, and R. Baker on the northwest quarter of section 27. Ed Snyder has considerable good gravel near the center of section 25, and Harry E. Yundt has some gravel on the southeast of the southwest of section 25. In general gravel is common along the Middle branch of Wildcat Creek.

On the northeast of the southeast of 27 and the northwest of the southwest of 26 there is a large deposit of gravel on Irwin Peters' farm south of the creek and on H. Hoffman's place north of the creek. It is a good material and easily accessible. On Calvin Peters' place, southwest of the northwest of 26, there is a great bluff of boulder clay that, within 40 rods, becomes a bluff of gravel. Browning Hill, on the southeast of the southwest of section 34, is apparently the highest point in the region. It seems to be made up mainly of fine sand with some gravel. There is an abandoned gravel or sand pit in the summit of the hill. This hill is perhaps a kame or other form of glacial deposit.

Fairfield Township.

This township, including the city of Lafayette, lies west of Perry and forms the greater part of township 23 north, range 4 west. The Parker gravel pit, on the southeast quarter of section 3, is in a large deposit on the east side of Wildcat Creek, near the river. There are 30 or 40 acres of gravel of unknown thickness. There is some cemented material, some fine sand and a few boulders, but in general the gravel is of excellent quality. Hilt's pit is on the east half of the northwest quarter of section 10, on the west side of Wildcat Creek. This pit is in a deposit 10 or 12 acres in extent. The exposure shows:

	Feet.
1. Soil and clay	2 to 4
2. Good gravel	10

The gravel is known to extend much deeper, at least below water level in the creek. The Heilman pit, the Dave Miller pit, and others on the northeast quarter of section 10, east of Wildcat Creek, indicate abundance of gravel along this stream. It really is more widely distributed than these pits indicate, for pits are opened only in the most available places.

Frey's pit is in an extensive deposit of gravel near the center of section 21. Nothing definite is known about its thickness or extent. This deposit has furnished large quantities of gravel to Lafayette for many years, and there are at least four or five acres remaining available for the future. The following section was exposed in the pit:

Section at Frey Pit.

	Feet.
1. Soil and yellow clay	2 to 8
2. Gravel	1 to 2
3. Yellow clay, about	4
4. Cemented gravel	1 to 2
5. Good gravel	15

There is some fine sand and a few boulders intermingled, but in general the gravel is of the best quality.

On the southwest of the southeast of section 29 there is a large deposit of gravel from which great quantities have been removed. An exposed section in Reed Beard's pit shows:

Section in Beard's Pit.

		Feet.
1.	Soil and yellow clay	2 to 4
2.	Yellow clay with pockets of gravel	2 to 3
3.	Yellow clay	2 to 3
4.	Thin layers of clay alternating with thin layers of gravel	3
5.	Blue clay with pebbles	3
6.	Yellow clay with pockets of gravel	2
7.	Fine gravel or sand exposed	15

The material is good for concrete or roads, but there is too much clay for profitable working at the present time.

On the east half of the northwest quarter of section 29 in the north bank of the creek there is a gravel or sand pit which shows the following section:

Section of Pit in North Bank of the Creek.

		Feet.
1.	Soil and clay, about	4
2.	Gravel	1
3.	Yellow clay	3
4.	Sand	1
5.	Yellow clay	3
6.	Fine gravel or sand exposed	10

On the south side of the creek there is a great bluff of clay as follows:

Section of Pit on the South Side of the Creek.

		Feet.
1.	Soil	2 to 3
2.	Yellow clay with thin layers of cemented gravel	30
3.	Coarse gravel	.5
4.	Blue clay	20

On the south side of this bluff, about 40 rods away, there is an abundance of gravel. On the southwest quarter of section 29, on the south part of section 30, and on the northwest of section 31 there is an immense body of gravel. There are pits on each side of the Wabash Railway in the southwest quarter of section 29 and Stidham's pit is on the northwest quarter of 31 (23 N., 4 W.). The gravel is of excellent quality. The interstratification of clay, sand and gravel found on the southeast quarter of section 29 does not appear on sections 30 and 31 in the pits opened. The gravel runs deep, at least to low water in the river, about 60 feet.

In the 15th Annual Report of the Indiana Department of Geology, page 87, Prof. Gorby says: "The area of the great basin in the central part of Tippecanoe County is not less than 250 square miles. This ancient basin is now filled with gravel, containing a small proportion of clay, sand and boulders. The following section of the drift at Lafayette is approximately correct:

Section of Drift in the Vicinity of Lafayette.

		Feet.	
1.	Soil	2	
2.	Sand	10	
3.	Gravel, clay and sand	70	
4.	Gravel, coarse	20	
5.	Gravel and boulders	20	
6.	Cemented gravel	40	
7.	Sandstone (cemented sand)	6	
8.	Cemented gravel and boulders	15	
	To surface at artesian well		183
	Section of artesian well		170
	Total		353

Other sections given by Prof. Gorby show a much larger proportion of cemented gravel than I saw, and a much less amount of blue and yellow clay. No accurate estimate can be made, but if the gravel only extends to water level, the amount about Lafayette is simply immense.

Sheffield Township.

This township lies in the eastern central portion of the county, and corresponds to township 22 north, range 3 west. The South branch of Wildcat Creek flows into the township from the east through sections 25 and 26 into 27, then turns north through the central portion of the township. Dayton, on sections 4 and 9, is the chief town of the township. Along the creek there are great bluffs of boulder clay with many small deposits of gravel, and this is generally of good quality. But the great body of gravel in the township is in the northwest portion in the vicinity of Dayton. The Dayton Mound, an esker, is the most conspicuous feature of this region. It is located mainly on sections 5, 6, 7 and 8. It is about 3/4 of a mile long, 1/4 of a mile wide and about 150 feet high, and is composed of sand and gravel, perhaps more sand than

gravel. The Lake Erie and Western Railway has taken immense quantities of material from this mound, and an interurban railway is now taking material from it for ballast.

To the east of the Mound on the southwest of the southeast of section 4 the railroad has an extensive pit. The deposit is at least 12 to 15 acres in extent and there are about 10 feet of gravel to water, and at least as much more below water level. In this deposit I found some rather rotten stones and some fine sand, but the railway people call it good material for their purposes.

On the northwest of the southwest of section 4 there is another pit in which there are 25 to 30 feet of gravel to water. The gravel in this pit seemed coarser than in the mound and of better quality than that in the railway pit.

From the Mound several pits were in sight, some of which were in hills that seemed to be kames or the remains of eskers. Among others are the Frends pit, on the northwest of the northwest of section 17, and Elliott's pit, on the southwest of the northeast of 18 (22 N., 3 W.). Northwest of the Mound there is a large deposit of gravel on the southwest quarter of section 6. It is covered by 2 or 3 feet of soil and has not been fully explored. On the northeast of the northeast of section 4 and the northwest of the northwest of section 3 there is a considerable deposit of gravel. In fact, sand and gravel are abundant everywhere in the northwestern part of Sheffield Township. The gravel along the creek in section 4 may be terrace formation, but it seems possible that the whole mass is of esker formation that has been spread out by the action of water.

On Catherine Baker's land, in the Richardsville Reserve, on what would be about northwest of section 22 and southwest of section 15, there is a large deposit of terrace gravel. As opened it seems good material. Gravel in the bluff on the east side of the creek from the terrace seems to rest on a bed of blue clay, while that in the terrace probably rests on the clay and is not very thick, not more than 10 to 15 feet. I saw and heard of several outcrops of gravel along the creeks that were so deeply covered with clay that they could not be worked with profit. Such deposits contribute largely to the sand and gravel found in the creek beds, which is often of very good quality.

Wea Township.

Wea corresponds to township 22 north of range 4 west. Wea Creek flows through the township northwesterly from section 35 to section 7, and Little Wea Creek drains four or five sections in the extreme southwest. There is some good gravel in the northeast.

The House pit, on the south half of the southwest quarter of section 12, and the Steckel pit, on the west half of the northwest of section 13, are in deposits that seem associated with those about Dayton. The Quaintance pit on the west half of the southeast quarter of section 17 shows the following section:

	Feet.
1. Soil and clay	1 to 3
2. Good gravel (to blue clay)	15 to 25

There are a few boulders and some fine sand, together with some cemented gravel. This pit is said to furnish excellent road material. The deposit has an extent of 40 to 50 acres.

The Richey pit, on the southwest of the northeast of section 27, furnishes some gravel, but is not much used. Elmer Waters, George Williams and others also have gravel pits along Little Wea Creek, in sections 30, 31 and 32. This gravel seems to be part of an old esker, trending toward the southwest into Randolph Township. The gravel is of good quality, making good road material.

Union Township.

This township borders the river on the north, and Wea Creek flows across its northeastern corner. There is said to be an abundance of gravel in the northern part of this township, but no pits of importance have been opened except along Wea Creek. The Wabash Railway has a large pit in the west half of section 1 (22 N., 5 W.). Jas. Vess, Will Bebee and Jas. Crow each have extensive pits in section 2. This deposit contains considerable sand and some cemented gravel, but in general it yields a good road material.

In sections 13, 23, 22 and 21 there is a range of esker-like hills of sand and gravel. There is a pit in High Gap Ridge, on the northwest quarter of section 22, and another on the northwest

of section 21 (22 N., 5 W.). The gravel is of excellent quality and of uniform size. John Griffin, on the southwest of the northwest of section 28, has several acres of good gravel. There are only about 12 feet of gravel exposed in the pit, but a driven well near by is 75 feet deep in sand and gravel. There is also an abundance of gravel on the southeast quarter of section 36 (23 N., 5 W.) and northeast of section 1 (22 N., 5 W.) in a continuation of the terrace down the river from Lafayette. A pit has been opened on the southeast quarter of section 36 by the Lafayette Gravel & Concrete Company which own 20 acres southeast of the crossing of the Monon and Wabash railways. The deposit has been tested to a depth of 65 feet. The material, as exposed in the bank, consisted mainly of uniformly coarse gravel, with very little sand. It is said to be good for concrete work.

The Monon Railway has a sand and gravel pit on the south half of section 1 and the north half of section 12 (22 N., 5 W.). This deposit of 700 to 800 acres is mainly of fine sand, a section being as follows:

Section of Monon Pit.

	Feet.
1. Soil and clay	3 to 6
2. Fine sand	12 to 18
3. Rather fine gravel	8 to 12

to water in bed of creek. This section is given as an illustration of the great variety of deposits about Lafayette. The Semple gravel pit is in a little kame or conical hill cut through by the road between sections 20 and 21 (22 N., 5 W.). The hill has an area of several acres. The pit shows 8 to 10 feet of uniformly coarse gravel, apparently extending much deeper. The grains of gravel were about the size of hazel-nuts and the deposit is said to furnish good road material.

Wayne Township.

The river flows along the north and northwestern margins of this township. Flint Creek flows across the central portion into the river. The kame or esker hills of Wea and Union townships extend into Wayne Township and there is an abundance of gravel in the central portions.

Acheson's pit, on the southeast quarter of 18 and the northeast of 19 (22 N., 5 W.), is in a large esker hill. In the northeast corner of section 19 there is a gravel pit, and there is gravel along the line between sections 17 and 20. Just north of West Point, on lots 5 and 6 of Burnett's Reservation, there is a large deposit of gravel. This deposit is at least 25 or 30 acres in extent and more than 20 feet thick. The gravel is of good quality but irregular in size with considerable sand intermingled. This pit is said to furnish good road material. There is gravel in the banks of Flint Creek in lot 1 of Burnett's Reservation. Also on M. E. Sherry's place on lot 2 of the reserve.

The Sherry pit as opened shows soil and clay 1 to 5 feet and gravel 12 to 15 feet, to clay. The material is very good, but uncertain in quantity. There is also an abundance of gravel in the Semple deposit, east half of section 20, and on the east half of section 29 (22 N., 5 W.).

Lauramie Township.

This township forms the southeastern portion of Tippecanoe County. It includes township 21 north, range 3 west and the east half of range 4 west. The main streams are Lauramie Creek in the northeast and Wea Creek in the west. Gravel is not very abundant in this township.

The Martin pit, near Stockwell, is one of the best pits in the township. It is on the northwest of the southwest of section 5 (21 N., 3 W.). The deposit comprises a low hill of sand and gravel of perhaps ten acres in area. About two acres have been worked over, several miles of road having been improved from this pit. The pit shows the following section:

Section of Martin Pit.

		Feet.
1.	Soil and clay with some coarse reddish gravel	1 to 3
2.	Sand and gravel, exposed	12 to 15

There is some fine sand and a few boulders. The material seems to be of good quality and is said to be good road material.

Near Concord, along Wea Creek, on the southwest of the southeast of section 2, and the north half of the northeast quarter of section 11 there is a deposit of sand and gravel. It is mainly below water level in the creek. A pit about 30 feet deep has been

scooped out on the northwest of the northeast of section 11 (21 N., 4 W.). The material is rather fine and does not pack very well, but the grains are largely quartz and will doubtless wear well. There is also gravel on Grove Givins' place on the northeast of 23 and on Wm. Morin's place on the northwest of 25 (21 N., 4 W.). In each case about 8 feet of gravel is exposed, which is said to be good road material, although it has considerable fine sand and a few boulders intermingled. There are at least four or five acres of gravel on the Morin place.

The Nydegger pit, on the west half of the southwest quarter of section 19 (21 N., 3 W.), shows soil and clay 1 to 2 feet and gravel of good quality, 8 to 12 feet exposed. There are at least three or four acres of the deposit. The pit is opened in good shape and the gravel is easily accessible. Mrs. Delia Waddell has a pit on the northwest of the northwest of 11. The gravel seems of good quality, but it has not been fully tested. On Geo. W. Switzer's place, on the southwest of the southeast of section 11, a pit is being opened in water gravel. The material appears to be first-class, but it has not been well tested. The Davis pit, on the northeast of the northeast of section 31 (21 N., 3 W.), shows as follows—

	Feet.
1. Black soil and clay	1 to 2
2. Gravel to water	5
3. Gravel under water	15

without reaching bottom. The material is rather fine, but it packs well and wears well. I heard several speak of it as excellent for road use. Mr. Davis thinks there are at least ten acres of the deposit, but knows nothing definite concerning its thickness.

Gravel pits on Ennis Coe's land, southwest quarter of section 21 (21 N., 3 W.), and Henry Shobe's land, southwest of 35 (21 N., 4 W.), have been abandoned, at least for the present, although the gravel has not been exhausted. No pits have been opened in the eastern portion of the towship. Lauramie Township has improved some roads with gravel from Sheffield Township.

Randolph Township.

Gravel is abundant in this township. The deposits in general seem to be in esker hills, some of considerable extent.

The Whipple pit, on the southeast quarter of section 31 (21 N.,

4 W.), is in a large deposit of sand and gravel. As opened the pit shows—

	Feet.
1. Soil and clay	1 to 2
2. Sand and gravel	10 to 12

There is considerable good coarse gravel in this deposit, but as a whole it seems rather fine for good road material and should be screened before using. It will then furnish material of good quality, which will wear well on the road. The deposit is a large one, extending into section 32, where another pit has been opened. This shows about 20 feet of gravel and is known as the Dan Simison pit. The material found in this is about the same as in the Whipple pit. The Stock Farm pit, on the southwest of 28, is another pit in the same deposit of gravel. This deposit on sections 28, 32 and 31 is thought to be an esker, extending westerly into Jackson Township.

M. F. Inskipp and G. C. Leaming each has a pit on the northeast of section 21 (21 N., 4 W.). The material is much the same as that from the Whipple pit, and probably is part of the same old esker. A well marked esker extending from the northeast toward the southwest through section 6 (21 N., 4 W.), and sections 1, 12, 11, 10 and 16 (21 N., 5 W.), contains large quantities of good gravel. Pits have been opened on sections 6, 1, 12, 11 and 10. The gravel in this deposit seems a little coarser than that on sections 28 and 32 above mentioned, and some call it better road material, but there is certainly no great difference.

Jackson Township.

There are numerous hills of sand and gravel in the southern and central portions of Jackson Township, possibly continuations of the Simison and Whipple deposit of Randolph Township. The most prominent feature in the topography of this township is the "Shawnee Mound." It is a great hill or mound of sand and gravel in the western part of the township on the northeast of the northwest of 23, southwest of the southwest of 14, southeast of the southeast of 15 and northeast of the northeast of 22 (21 N., 6 W.). It is mainly in section 22. The mound is quite symmetrical in form, rising 80 to 90 feet above the surrounding country, and has an area of 10 or 12 acres. Not only is the mound

composed of sand and gravel, but a considerable area of surrounding land is underlain with 15 to 20 feet of the same material. Over the mound there is from 1 to 6 feet of soil and clay, while from 3 to 6 feet of black soil covers the surrounding gravel. There is a large pit near the summit of the mound. As opened the pit shows more sand than gravel, but it seems to be of good quality and is said to make good roads.

There are several other pits in the vicinity, namely: The Duncan pit, on the northeast of the northeast of section 11; the Wray pit, on the northwest of the northwest of 6; the A. Wallace pit, on the southwest of the southeast of 24, and the Abe Meharry pit, on the southeast of 3 (21 N., 6 W.); also the B. Simison pit, on the west half of the northeast quarter of section 20; the W. Boland pit, on the northwest of the southwest of 28, and the James Stewart pit, on the north half of the northeast quarter of section 30 (21 N., 5 W.). The material in these different pits seems to be of good quality, but in general, unless screened, there is too much sand for first-class road use. The fine material is quartz sand and it wears well, so that the "bank run gravel" makes a fairly good road material.

WARREN COUNTY.

Area in square miles	366
Population in 1900	11,371
Miles of public roads	610
Miles of improved roads	186
Percentage of roads improved	30.5
Miles improved with gravel	186
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$2,100
Total original cost of improved roads	$390,600
Annual cost of repairs per mile on gravel roads 5 years old	$100
Miles of improved road (gravel) built in 1905	32
First improved roads built	1884
Proportion of improved roads built since 1895 (per cent.)	45
Satisfaction of farmers with investment in improved roads—	"Most generally are well satisfied"

Authorities—

R. L. Winks	County Auditor
W. H. Gemmer	County Surveyor

Warren County lies on the western border of the State, and is bounded on the north by Benton County, on the west by Illinois and a small part of Vermillion County, on the south by Vermillion County, on the southeast by the Wabash River and on the east by Tippecanoe County. It is divided into eleven townships—Medina, J. Q. Adams, Pine and Prairie on the north, in township 23 north; Warren, bordering the river; Liberty and Jordan, in township 22 north; Washington, Pike and Steuben, in township 21 north; Kent and Mound, extending from the river to Illinois, in township 20 north.

The county is drained by several small streams flowing into the Wabash. In the east Little Pine Creek drains Medina and the east part of Warren Township. Kickapoo drains Adams and the western part of Warren, while Pine Creek drains Pine Township, part of Adams, and Liberty Township. Rock Creek, between Washington and Pike Townships; Redwood, between Pike and Steuben; Possum Run, in Steuben, and Spring Creek, in Mound Township, are the principal streams. Prairie and Jordan Townships are drained by Jordan Creek, a tributary of the Vermillion River in Illinois.

There is a narrow flood plain along the Wabash River, then a terrace, or second bottom of sand and gravel, then the uplands. The uplands fronting toward the river are somewhat broken, and there is considerable broken country along Pine Creek in Liberty Township, but in general the northern and western parts of the county are rolling prairie lands.

The shales and sandstones of the Coal Measures outcrop along the streams on the river side of the upland, but in general they are deeply covered with drift, perhaps as much as 100 feet in thickness. The county in the north and west has an elevation of about 700 feet, rising about 200 feet above low water in the river. Rock is common in the bluffs and sometimes in the bed of the river from the east line of the county, southwesterly five or six miles to Independence. Below Independence the bed of the river seems to be of sand and gravel.

Medina Township.

Medina Township has but little gravel and but few miles of gravel road. The roads were improved with gravel from the banks or bed of Little Pine Creek, from small local pits and from "Indian Hill," in Tippecanoe County. On the northwest quarter of section 28 (23 N., 6 W.), near Green Hill, Jacob Mann has a small pit. The gravel is from 7 to 10 feet thick and of good quality, but it is covered with from 8 to 12 feet of soil and clay, so that it can not be profitably worked except along the outcrop. Gravel is reported on the northeast quarter of section 28, but it has not been developed, and nothing is known of its extent or depth. W. E. Cooper has three or four acres of gravel on the northwest quarter of section 32 (23 N., 6 W.). It is 12 to 18 feet deep and is said to make a good road. It has not been very well developed. There is also some gravel on the northwest quarter of section 17, but it contains a great deal of sand and soil, so that it is not considered of good quality.

Johnson's gravel pit and Harvey and Franklin's pit, on the southwest quarter of section 29, show 8 to 10 feet of gravel to water, but the stripping is heavy and the gravel can not be worked with profit. It is called good road material. The area of the deposit is quite extensive, but not definitely known, and is deeper than the deepest wells. Roads in this township are being improved with imported gravel.

Adams Township.

There are a few small gravel pits in Adams Township, but none of importance. Some roads have been improved with material from local pits, but repairs are made with gravel shipped from Kickapoo, in Warren Township, or from Indian Hill, in Tippecanoe County.

Pine Township.

Some roads in Pine Township have been improved with gravel from local pits. Will Hurst, George Hillyerd, Frank Brian, Lillie A. Gray and others in the neighborhood of Rainsville, sections 20, 21, 22, 23, etc. (23 N., 8 W.), have furnished gravel

for roads, but repairs are generally made with material from Kickapoo, in Warren Township.

Prairie Township.

There is no bank gravel in Prairie Township that could be called workable. Some roads have been improved from local pits, but these seem exhausted, so that the repairs in general are made with gravel from Kickapoo.

There are some deposits of water gravel, but they have not been well explored and little is known of their extent or quality. They are pumping gravel from a pit on section 30 (23 N., 9 W.), but it is not of a very good quality. There is some gravel in section 12 (23 N., 10 W.), in the northwest part of the township, but it does not seem to be of special value. There is an old pit on the Vennum land, northwest quarter of the southeast quarter of section 36 (23 N., 9 W.). It is in the top of a hill some 40 feet high. The deposit is perhaps six or seven acres in extent and some 15 to 18 feet of good gravel is exposed in the pit, also some sand and a few boulders.

Gravel is reported on Harrison Goodwin's land, on the northeast quarter of section 30, and on John Carlson's land, northwest quarter of section 21 (23 N., 9 W.). Other deposits were mentioned, but none were well developed and none appeared to be of much importance.

Warren Township.

On the southeast quarter of the southeast quarter of section 5 (22 N., 6 W.), there is an acre or so of good but rather fine gravel, perhaps 10 feet deep. It is covered with only a foot or two of soil, is easily accessible, and is said to make a good road. This gravel is part of a ridge extending about a quarter of a mile eastward into section 4. The ridge seems to be made up largely of sand, with some gravel. A little pit on the southwest of the southwest of section 4 shows a fine quality of coarse sand, highly prized for concrete work. There is some gravel on the northeast of the northwest of section 4 on Wm. Young's land, and on the northeast quarter of the same section is the Francis pit.

In the bank of Little Pine Creek, on the southeast quarter of

section 5, on the Banning land, there is an extensive deposit of gravel or of sand and gravel, mixed with considerable soil. In making an approach to a bridge a deep cut was made through this deposit and some three or four miles of road were improved with material taken out, but it is not called good road material. The deposit is perhaps ten acres in extent and 20 feet deep, with but little stripping. The road made from this pit seemed fairly good, but appears to be wearing out rapidly. On the southeast of the southeast of section 7, Clarence Dawson has two or three acres of good gravel, but it is covered with six or seven feet of soil, so that it can hardly be worked with profit. There are several other small banks of gravel along Little Pine Creek, but none of importance.

On the northeast of the northeast of section 23 (22 N., 7 W.), near Independence, there are two hills of gravel about an acre each in extent, owned by Jade Steadman. The gravel is from 1 to 16 feet thick and makes a good road. The Independence and Clawson road, about four miles in length, was made from this deposit.

There is a gravel pit on the northeast quarter of the southeast quarter of section 29 (22 N., 7 W.), which has yielded large quantities of gravel. The material is of good quality, with some fine sand and a few boulders mixed through it. Nothing definite is known as to the depth or area of this deposit. There are at least from 80 to 100 acres of gravel from 75 to 100 feet thick. It is part of the bank of the valley of Kickapoo Creek, where it opens into the valley of the Wabash.

Northeast of this deposit up the valley in section 21 (22 N., 7 W.), a well shows soil three feet and gravel 73 feet. On section 22, on Mr. King's land, the gravel in a well of about the same depth was separated into distinct beds or layers by strata of clay. Mr. H. L. Winks, a well digger, says that there are at least two sections, or 1,280 acres, of land underlain with thick beds of gravel, as shown by wells which he has dug or which he has known personally.

On the west side of Kickapoo Creek on the east half of section 30, the west half of section 29 and the east half of section 20, there is an abundance of good gravel. The Chicago & East-

ern Illinois Railway runs over this land, and the railway people have opened a large pit in sections 20 and 29. William Douglass has a pit on section 29, and Mrs. Lindsey has some 20 acres of gravel on the southeast of section 20. H. L. McKenzie has 40 to 50 acres of gravel in the south half of section 20, and Robert Milligan has considerable gravel in the southeast of 30 and the northeast of 31 (22 N., 7 W.). This gravel is of good quality, but contains considerable sand and a few boulders. Near the surface there are many large masses of cemented gravel. The railway people break these up and use the material for riprapping, etc. This cemented portion does not extend very far back into the deposit. Nothing is known as to the depth of the deposit.

Malady's gravel pit, on the southwest quarter of section 17 (22 N., 7 W.), is in a large deposit of sand and gravel from 15 to 20 feet thick. In it there are many small boulders. The deposit is covered by from 2 to 4 feet of soil and clay. T. A. Barns has a pit on the northeast quarter of section 16, but it is not very large. The gravel is abundant in section 20 and in the south part of 16, and runs deeper than the deepest wells. On the west half of the southeast quarter of section 2 (22 N., 7 W.), Henry Brutus has a well showing—

	Feet.
1. Soil and clay	80
2. Fine sand	118

to water and sand. No bed rock at 198 feet.

Liberty Township.

Pine Creek runs through this township and much of its area is broken. In general the bluffs are of boulder clay, sometimes of rock, but occasionally there are deposits of gravel. On the northeast of the northeast of section 22 (22 N., 8 W.), J. P. Bennett has a gravel pit. J. P. Hunter has one on the southeast of the northwest of section 23; H. L. Kramer one on the southwest quarter of section 23; William Johnson one near the center of section 22, and Charles Dick one on the southeast of the northwest of section 22. Newton McClure has four or five acres of gravel on the northwest of the northeast of section 27. There are doubtless other deposits, but the ones mentioned furnish most of the

road material used in the township. These deposits are often deeply covered with boulder clay, so that little is known of their extent. In some cases there are 30 to 50 feet of gravel down to the level of the creek bed. Mr. Johnson thinks he has about 25 acres of gravel at least 50 feet thick. The gravel is of good quality, but contains some fine sand and a few boulders. It is called good road material, as it wears well.

Several pockets of gravel occur on Sam Creamer's place, on the southeast quarter of section 9 (22 N., 8 W.). Some are good and some not very good. None of them are well developed. William Bottorff, on the northwest of the northwest of 7 (22 N., 8 W.), has a hill with 12 to 15 feet of gravel to water. The deposit extends onto adjacent land, covering an area of five or six acres. It extends at least ten feet below water level. Part of that above water level is rather dirty, but is called good road material. There is a small deposit on the northwest of the southwest of section 6 called good gravel, but it has not as yet been developed.

Jordan Township.

No bank gravel was found in this township, but several deposits of water gravel are known to occur. William Sibbits has a pit on the southeast quarter of the northeast quarter of section 12 (22 N., 10 W.), which shows soil and clay 2 to 3 feet and fine gravel or sand 2 to 13 feet. Similar material occurs on the northwest quarter of the northeast quarter of section 12. Not much is known about the area of these deposits, but Mr. Sibbits thinks he has at least 10 acres of workable gravel in the southeast of the northeast of section 12. The material is very fine, really sand, but, contrary to expectation, makes a very good road material, and would make a better if it were screened. At first Mr. Sibbits pumped water and shoveled gravel, but soon thought it more profitable to pump the gravel.

On the northeast quarter of section 17, on the northwest quarter of section 16, and on sections 8 and 9, all in township 22, range 9 west, there is an extensive deposit of water gravel. A pit has been opened on the northeast of the northeast of section 17 (22 N., 9 W.), on the land of Harry Pense. Soil about 3 feet covers gravel 10 to 14 feet. It is of excellent quality and makes

good concrete, but it is rather fine for ideal road material. Not much is known about the extent of the deposit, but it underlies at least 1,000 acres. This deposit was opened in the season of 1905. There is also good gravel on the south half of section 32 (22 N., 9 W.).

The wells in this township show considerable deep gravel. One in the north half of section 31 (22 N., 9 W.), shows 85 feet of soil and clay and 25 feet of gravel. Another in the same neighborhood shows 72 feet of soil and clay and 9 feet of gravel. A third on the Hedrick land, southeast quarter of section 36 (22 N., 10 W.), shows 80 feet of soil and clay and 25 feet of gravel, while a fourth on the John Crawford farm, northwest of northwest of 36, shows 75 feet soil and clay and 25 feet of gravel.

On the northeast quarter of section 10 and the northwest quarter of section 11 (22 N., 9 W.), the wells show clay and soil of varying depths, 5 to 25 feet, then gravel from 30 to 50 feet, over an area estimated at 200 acres.

Washington Township.

This township borders on the river and has considerable gravel on or in the second bottom. There is an abundance of gravel on both sides of the railway in sections 10 and 11 (21 N., 8 W.). The gravel in this deposit runs deep and is of good quality. There is also a plentiful supply on the east half of section 29 and the west half of section 28 (21 N., 8 W.), on the lands of D. B. Crane, Wilmer Schaefer and George Bowlus. No extensive pits have been opened in the south part of this township, but pits in the same deposit a little farther west show the gravel to be of good quality. Wells show this gravel on sections 28 and 29 to be more than 90 feet thick. It may not be as good as that along Kickapoo Creek, but it is called good road material. There is doubtless considerable gravel between sections 10 and 28 in this township, but none has been developed.

Pike Township.

Pike Township borders on the river and has some terrace gravel. William Brennan has a pit on the northeast quarter of the southwest quarter of section 29; T. H. Crane one on the southwest quar-

ter of the northeast quarter of section 30; Mrs. Warrenfield one on the southeast of the northwest of section 30, and Geo. W. Beggs one on the northwest of the southwest of 31 (21 N., 8 W.). All are on the terrace, each showing good gravel. There is some gravel along the streams, but the pits mentioned are the only ones of importance in Pike Township.

Steuben Township.

Not very much gravel occurs in Steuben Township. There is a pit on the Van Leers place, near the creek, in the east half of the northeast quarter of section 22 (21 N., 9 W.), showing soil and sand 5 to 7 feet, and gravel 12 to 18 feet. The gravel is dirty, contains many flat pebbles and bits of shale and some rotten stones. The road running east and west about one mile north of Marshfield was improved with material from this pit. It makes a fairly good road for light travel.

Some gravel is taken from the creek bed on Bent Reynolds's place on the east half of the northwest quarter of section 26 (21 N., 9 W.). The road through Marshfield was made from gravel taken from the Reynolds pit, on the William Smith land in the eastern part of Steuben Township. Some gravel has also been taken from the Starry pit on the southwest quarter of section 18 (21 N., 9 W.), but it is not very good road material.

Kent Township.

The second bottom is narrow in this township, and gravel is not common. Several pockets of gravel of small size occur along the bluffs, but no pits of importance have been opened.

Mound Township.

There is an abundance of good gravel in the southeast portion of Mound Township. On the Dave Talbot place in the north part of section 28 (20 N., 9 W.), and on the Richey place, in the southeast of 28, there are quantities of good gravel. The Big Four Railway has extensive gravel pits on the southwest quarter of section 27. Some of this gravel is very fine quality. There must be more than 100 acres of good gravel in sections 27 and 28.

There are no other pits of importance in the township, but there is doubtless plenty of gravel in sections 33 and 34 (20 N., 9 W.). In Kent and Steuben townships the bluffs toward the river are generally of boulder clay, with pockets of gravel, and there is considerable terrace gravel. There is but little gravel in the western part of Kent and Mound townships. Much of that in sections 27 and 28 probably extends below water level.

FOUNTAIN COUNTY.

Area in square miles	383
Population in 1900	21,446
Miles of public roads	1,200
Miles of improved roads	502
Percentage of roads improved	41.8
Miles improved with gravel	500
Miles improved with crushed stone	2
Average original cost of gravel roads per mile	$2,000
Average original cost of stone roads per mile	$2,500
Total original cost of improved roads	$1,005,000
Annual cost of repairs per mile on gravel roads 5 years old	$100
Annual cost of repairs per mile on stone roads 5 years old	$100
Miles of improved roads (gravel) built in 1905	50
First improved roads built	1883
Proportion of improved roads built since 1895 (per cent.)	40
Satisfaction of farmers with investment in improved roads*	Good
Authority	Jas. T. Bell, County Auditor

*A very large per cent. of the farmers would prefer having the roads placed back on the townships, as they could be taken care of better and cheaper.– J. T. B.

Fountain County borders on the Wabash River, which separates it from Warren County on the northwest and from Vermillion County on the west. Parke County is on the south and Montgomery and Tippecanoe bound it on the east. The principal streams are Big and Little Shawnee Creeks in the north; Coal Creek and its tributaries draining the central portion, while the Mill Creeks drain the southern part of the county. Low water in the Wabash at Attica is about 500 feet above tide, while at Covington it is 491 feet. Hillsboro, in the eastern part of the county, has an elevation of 728 feet, and hills about Attica have about the same elevation.

The surface is rugged along the larger streams, but in general it is a gently undulating plain, sloping toward the river. There

are great quantities of sand and gravel in the terrace along the river. In the northern portion of the county there are a number of hills, made up largely of sand and gravel. These hills may be kames or remains of eskers, and in formation were doubtless associated with similar hills found in Tippecanoe County. These hills contain large quantities of gravel. Along the larger streams there are many deposits of gravel, put down in glacial times perhaps, but opened up by the erosive work of the streams. In the larger streams there are frequently deposits of good gravel put down by the present streams from subsiding floods.

In general the county is well supplied with gravel of a good quality. On section 28 (18 N., 8 W.), there is an outcrop of hard limestone in the banks of Wabash Mill Creek that would doubtless make good road material, and on section 16 (22 N., 6 W.), there is a large bed of flint rock that makes an excellent road material.

Davis Township.

This township is in the northeastern portion of the county, bordering on the river. It extends northerly about seven miles from the middle of township 21 north. The river bluff is largely of boulder clay, although sandstone strata outcrop in many places.

The Flint bar, on the bank of the river in the southwest of 16 (22 N., 6 W.), has an area of about 100 acres. The upper three or four feet consists of flint rock that has been broken in fragments ranging from three inches downward. Then there are three or four feet of unbroken rock to shale. This broken rock has been used extensively in making streets in Lafayette and in making roads. For many years the material was used as found in the bar, but a few years ago the Western Construction Company installed an extensive plant and began crushing the stone, screening it into desired sizes and washing it, thus putting it into much better form for use. For some time a large business was done, but for some reason the work has been abandoned, at least temporarily.

The flint is sometimes used as a foundation and covered with sand or fine gravel as a binder. In other cases somewhat finely pulverized flint it is used as a binder or top dressing. G. H. Steven-

son, engineer, says the flint wears better than limestone, is not so dusty, and that the dust formed is not so irritating as the lime dust. Mr. Stevenson said the flint was especially used for improving the steep grades so common in Lafayette. The bar is flooded by very high water. I could get no idea of the extent of the flint rock, but heard of outcrops about three miles south of West Point, in Tippecanoe County. Samples of the flint were tested in the laboratory of the U. S. Department of Agriculture at Washington, with the following results:

*Results of Physical Tests of Flint from near Attica, Fountain County.**

Specific gravity.................	2.5	French coefficient of wear.	13.5
Weight per cu. ft..........(lbs.)	152.8	Cementing value—Dry....	2
Water absorbed per cu. ft..(lbs.)	2.83	Wet....	15
Per cent. of wear.............	3		

"Good resistance to wear and fair cementing value. Not sufficient material for hardness and toughness tests."—Page.

An analysis of the flint was made at the same laboratory, with the following results:

Analysis of Samples of Flint from near Attica, Fountain County.

	Per cent.
Alumina (AlO)	1.00
Iron oxide (FeO)	.25
Lime (CaO)	2.25
Magnesia (MgO)	.80
Insoluble in hydrochloric acid	91.47
Loss by ignition	4.39
Total	100.16

This flint rock has been used for street improvement in Lafayette on Perrin Avenue and on Ninth Street; on the Sixth Street hill, on Fourth Street and on Heath Street, between Sixth and Ninth.

Along the bluff there are occasional deposits of sand and gravel. On the southeast quarter of section 16 there is an abundance of sand, but no gravel. It seems possible that there might be some gravel in this deposit.

On the southwest of section 30 (22 N., 6 W.), there is a large

*See page 79.

deposit of gravel, in which the Funk pit has been opened. The exposure shows—

	Feet.
1. Soil and clay	1 to 2
2. Gravel	8 to 10

In this deposit there is considerable fine sand and a few boulders. In it I found many rotten granite and ironstone pebbles, so that it could hardly be called first-class road material. The roads made of it are smooth and hard, and seemingly wear well under ordinary traffic. The deposit is thought to be at least 20 to 25 feet thick, and to have an extent of six to eight acres.

The Thompson pit is on the northwest quarter of section 25 (22 N., 7 W.). There is here a small deposit of gravel which contains considerable sand and some clay. As opened there are only five or six feet of gravel, which is not much used.

Thompson's pit, on the southwest of the southwest of 36 (22 N., 7 W.), is in quite a large deposit of fairly good gravel. It extends into section 1 (21 N., 7 W.), and into the adjoining sections on the west. No gravel has been taken from this deposit for several years. The road on the line between section 36 (22 N., 7 W.), and 1 (21 N., 7 W.), cuts through a hill that shows some gravel toward the top. On the northeast of the northeast of 1 about 15 feet of gravel is exposed in the Morgan and Britt pits. The area is probably not more than two acres. There are perhaps three or four acres in section 36, across the road. It does not seem to be very good gravel, but is said to make a fairly good road. There is a gravel and sand hill or ridge on the south part of the northwest quarter of section 1 (21 N., 7 W.), which may be a kame or part of an old esker, but no pit has been opened in it. There are other deposits of gravel reported in the southern part of the township, but there are none of much importance. The E. B. Hughes pit on the southeast of 4 (21 N., 6 W.), and the Waldrip pit on the southeast of the northeast of 12 (21 N., 6 W.), have furnished some road material.

Logan Township.

This township borders on the river and lies west of Davis Township. The bluff in the north is largely of boulder clay, with many boulders and a few small pockets of gravel. Sandstone out-

crops at several places along the bluffs. Great quantities have been quarried on section 26 (22 N., 7 W.). Much of this is hard sandstone and might make good material for the foundation of a road. The city of Attica stands on a great mass of gravel. The wells show gravel 95 feet below low water mark, while the reservoir on a gravel hill is 215 feet above low water. The city reservoir and Arms gravel pit are on the southwest of the southwest of 5 (21 N., 7 W.). On the northwest of section 5 there is considerable gravel, but not very thick, only 20 to 30 feet to rock. On the southwest and northwest of 7 and on the west half of 8 gravel is abundant. Pits opened show soil and clay 1 to 6 feet, sand and gravel to bed rock, 40 to 50 feet. An eight-acre swamp or swale, on the southeast of the northwest of 8, shows—

		Feet.
1.	Muck	1 to 2
2.	Clay	5 to 16
3.	Sand and gravel	30 to 40

Young's pit, on the northwest of the southwest of 7, is in the edge of the terrace, where a face of 30 feet of gravel is shown. The area is not known, but it must be extensive. The gravel is of fine quality, but it contains a great many small boulders.

The Wabash Railway has opened a great sand and gravel pit along the terrace in sections 12 and 13 (21 N., 8 W.). There are about 80 feet of gravel exposed in the pit. The material from this pit is called good for road making, for cement work and for plastering. Looking eastward from the reservoir at Attica, one may see several conical-shaped hills, which, on investigation, appear to be kames or eskers, and generally contain gravel.

The Slusser gravel pit, on the northwest of 3, and the Leasure pit, on the northeast of 3 (21 N., 7 W.), are in kame-like hills, and there is an esker hill of gravel and sand on the northeast quarter of section 2 (21 N., 6 W.), on which stands a school house, church and cemetery. There is a gravel pit on Mrs. Huddle's land in the bank of Nave Creek, in the southeast of the southeast of 14 (21 N., 8 W.), which exposes an abundance of gravel of good quality. Along the road south, between sections 7 and 8, 17 and 18 (21 N., 7 W.), the telephone poles are frequently set in the gravel.

Shawnee Township.

This township has a river front of about four miles. There is considerable gravel along the terrace in sections 22, 23 and 27 (21 N., 8 W.), but it is not as abundant as it is farther north. There is also gravel along the Big Shawnee Creek in section 23, but I saw no gravel pits.

The Orland pit, on the southeast of the northeast of 27 (21 N., 8 W.), appears to be in a large deposit. The pit shows soil and clay 2 to 3 feet and gravel 10 to 12 feet to level of water in the branch. There is some fine sand and many boulders, but there is a large proportion of coarse gravel of good quality. It is called good road material. There is an abundance of good gravel along the Big Shawnee in section 24 (21 N., 8 W.), and on section 19 (21 N., 7 W.). The gravel is of good quality, but the deposit is not very thick, not more than 10 or 12 feet. John L. Foster has a large area of sand and gravel in section 30 (21 N., 7 W.). The deposit yields an excellent material for cement and plaster, but is rather fine for road material. The Galloway pit on the southwest of section 11 (20 N., 8 W.), furnishes some fairly good gravel. In the southeastern part of the township considerable gravel from the bed of Coal Creek is used for road material. Gravel of very good quality is found on the northwest quarter of 8 and the northeast of 7 (20 N., 7 W.). Some consider this stream gravel as good or better than bank gravel.

There is some gravel along the Shawnee creeks in the eastern part of the township, but no good pits have been opened. In general the pits in Shawnee Township yield more sand than gravel, but the material is of good quality and wears well. Some gravel occurs along Bear Creek, on the southeast of section 32 (21 N., 8 W.), but no pits were seen. Along Bear Creek there is an abundance of good sandstone. There is a good supply of gravel on the Evans Claypool place on section 21 (21 N., 7 W.), along the Big Shawnee.

Troy Township.

This township has a river front of about twelve miles. Covington, the county seat, is the chief town, and is situated on the bank of the river. There is an abundance of gravel in the terrace in the northwestern part of the township.

On George Hunt's place, in the northwest of section 5, there is a great body of good gravel, and there is also a deposit of similar material on the southeast of section 6 (20 N., 8 W.). A large part of sections 12, 14 and 23 (20 N., 9 W.), and parts of adjoining sections consist of sand and gravel from 75 to 140 feet thick to water level in the river. A pit has been opened on the northeast of the southwest of 12, on R. S. Nebeker's land. The gravel is of excellent quality, but rather fine for good road material. John Bilsland also has a pit on the northwest of 24 and another on the north half of the southeast quarter of section 22, while E. H. Nebeker has a third on the east half of the southwest quarter of section 24 (20 N., 9 W.). The supply of good gravel in this region seems to be unlimited.

The McCabe pit, on the northwest of the northeast of 36 (20 N., 9 W.), furnishes great quantities of good gravel. It is in the suburbs of Covington, and is said to yield better material than any other pit in the township. The DeHaven gravel pit is on the east half of the southeast quarter of 30 (20 N., 8 W.). This pit yields large quantities of medium quality gravel. The Anderson pit on the southwest of the southwest of 12 (19 N., 9 W.), furnishes also an abundance of gravel, but rather fine for first-class road material. John Tamberlane and others in this region have good gravel. Troy Township gets some gravel from the Galloway pit in Shawnee Township and some from the Hepler pit in Van Buren Township. There is not much gravel in the southeastern portion of the township.

Wabash Township.

The bluff along the river in this township is largely of boulder clay. The pockets of gravel are few and small.

There is quite a large deposit of sand and gravel in the lands of E. R. Marlatte and others, mainly on the northwest quarter of 29, and the southwest of 20 (19 N., 8 W.). On the Marlatte land, on section 29, is the Buckhorn pit. It is on the bank of a branch of Coal Creek. There are perhaps 20 acres in this deposit. The pit as opened shows: Soil and clay, 1 to 3 feet, and gravel, 10 to 12 feet. Another pit in the same deposit shows about the same material. There is some sand and a few boulders, but the material is of good quality and makes a fairly good road.

Mr. Wells, on section 20, has an abundance of gravel, much like that on 29. It is called good road material. This deposit, something like a terrace along the creek, is the chief source of bank gravel for Wabash Township. Considerable gravel is taken from the bars of Coal Creek for road purposes. A good quality is found near Snoddy's Mills, on the southeast of section 1 (18 N., 9 W.), but it does not pack very well and is not considered first-class road material. Wabash Township also gets some gravel from the Ratcliff pit, in Fulton Township, and some from the Patton pit, in Van Buren Township.

Fulton Township.

This township forms the southwestern portion of Fountain County. It borders on the river for about five miles. Coal Creek flows southerly across the township just west of its center, and Wabash Mill Creek flows across the southeastern part of its area. These streams and the river give Fulton Township considerable broken surface. Sand and gravel are quite abundant.

The Richardson pit is on the southeast of the southwest of section 7 (18 N., 8 W.), in a deposit of four or five acres of gravel. As opened the pit shows soil and clay 1 to 3 feet and gravel 12 to 15 feet. It is called good road material. On the northwest of the northwest of section 7 there is a large deposit of sand good for plaster and cement. About the corners of sections 7, 8, 17 and 18 there is a deposit of gravel in which several pits have been opened by Elwell, Getts & Hardesty. This deposit yields fairly good road material. Samuel Cates's pit on the southeast of section 9 (18 N., 8 W.), furnishes material that contains too much sand.

The following pits in this region all supply a good road material: The Burnside pit, on the southeast of section 13; the Charles Guy pit, on the southwest of 24; the McLean pit, on the southeast of 36; the E. M. Waterman pit, on the southwest of 35; the Samuels pit, on the southwest of 23; the Ratcliff pit, on the southeast of the southwest of 10, and the J. Hathaway pit, on the northwest of 23 (18 N., 9 W.).

The Clover Leaf Railway has a large pit on the east half of section 34 (18 N., 9 W.). They have worked over 15 to 20 acres of gravel. As shown in the pit, there is—

Section of Clover Leaf Pit.

		Feet.
1.	Soil	1 to 3
2.	Sand and gravel	18 to 20
3.	Boulder clay and boulders	12
4.	Bed rock	......

In the edge of the terrace near the river there is another deposit of gravel at least 40 feet thick and several acres in extent. The deposits seem much alike, are both of excellent quality and are near one another, but the railroad gravel is above that by the river. The railway pit is on a rock, the south end of Silver Island. The island is three or four miles long from north to south and about one mile wide. Several gravel pits have been opened in the deposits along this ridge. In the railway pit there are a few boulders and considerable sand. In one region of the pit a great many clay boulders are found. They are composed of different kinds of varieties of boulder clay, and reach a size of two and a half to three feet.

The George Towell pit, on the northeast of 28 (18 N., 8 W.), near the falls of Wabash Mill Creek, shows 2 to 3 feet of soil and clay and 10 to 12 feet of good gravel to water. The gravel extends considerably below the level of the rock at the falls, and may be in an ancient channel. About three acres have been worked over and there is as much more available. Quite as much gravel goes from this pit into Mill Creek Township as is used in Fulton Township.

The falls in Wabash Mill Creek are caused by a stratum of hard, blue limestone, seven to nine feet thick, that rests on a bed of shale. It might make good road material and is more promising than any other I saw in the county. A large area could be worked without the expense of stripping.

Mill Creek Township.

The surface of the township is quite uniform, there being no large streams and but little broken ground. The supply of gravel is rather scanty.

M. Little's pit, on the northwest of 27 (18 N., 8 W.), contains two or three acres of gravel perhaps 10 feet thick. It is of fairly good quality and many think it is the best in the township.

The Reath pit, on the southwest of 32 (19 N., 7 W.), near Steam Corner, has been sunk about 15 feet to water. The gravel below water level is of good quality, but the depth is not known. Some gravel from the bed of Mill Creek is used in repairing roads. The township gets gravel from Fulton, Van Buren and Jackson Townships.

Limestone from a quarry near Yeddo, on the southwest quarter of section 7 (18 N., 7 W.), has been used to some extent for improving roads. The rock is hard, but it splits into flakes, thin and wide, not a very good form for road material. The mile or so of road improved with it is not ideal, but it does not seem to have been well made, so that the material has not had a good chance to show its fitness.

Van Buren Township.

Veedersburg is the chief town of the township, and Coal Creek, with its valley, are the dominant features in the topography. In the banks and bed of the creek there are sandstones, shales and coal. There is also an abundance of boulder clay, with large quantities of sand and gravel.

Near Stone Bluff, John M. Meeker has a gravel pit on the northwest of the northwest of 19, and two on the southeast of 18 (20 N., 7 W.). Apparently the gravel is abundant, but nothing very definite is known as to its extent or depth. It only makes a medium quality of road material. Stream gravel, mainly from Coal Creek, is used to some extent in this township. On section 12 (19 N., 8 W.), southwest of Veedersburg, there is a great mass of gravel in the edge of the terrace or bluff. James Songer and Richard Hatfield have pits in this deposit. The pits show 1 to 2 feet of soil and clay and 15 to 20 of gravel exposed. There are some boulders and considerable sand, but in general the material is very good for road building. There are probably 50 or 60 acres in the deposit, and it may go deep below water level. There is gravel on the southwest quarter of the section, and also at places along the railway between Stone Bluff and Veedersburg.

Volney Patton, on section 24 (19 N., 8 W.), and William Dice, on the west half of section 19 (19 N., 7 W.), each have an abundance of good gravel. In general it is abundant along Coal Creek.

Richland Township.

This township extends through township 20 and three sections into 21 north, and is in ranges 6 and 7 west. It is drained by the branches of Big Shawnee and Coal creeks, but the valleys are not deep and the surface is quite uniform. Considerable of the gravel used for road purposes is taken from the beds of the streams. Sand and gravel are widely distributed, but there is very little first-class road material in the township.

John Neal, on section 26 (20 N., 7 W.), has a large deposit of gravel, 10 to 12 feet thick, but it is rather fine for road material. Several miles of road have been improved from this deposit, and there are several acres left for future use.

Will Gallagher's pit on section 19 (20 N., 6 W.), shows much the same material as is found in the Neal pit, but it is considerably thicker as opened. Sand of good quality for plastering or cement work is abundant in this deposit. The Broderick pit, on section 21, is in a deposit of two or three acres of medium material, about 12 feet thick. The Keyte pit, on section 17, and the Coon pit, on section 7 (20 N., 6 W.); the Parnell pit, on section 19, and the Dodge pit, on 21 (21 N., 6 W.), all furnish material of a medium quality. The Bookwalter pit, on section 2 (20 N., 7 W.), is in a deposit of several acres of what is called good road material. The soil and clay are from 4 to 6 feet thick above 8 feet of gravel. It can not be worked with much profit.

Cain Township.

This township is drained by a branch of Coal Creek. Hillsboro is the chief town. There is considerable sand and gravel in the township, but it makes only fair road material.

Jake Hesleve, on the southwest quarter of section 27 (19 N., 7 W.), has four or five acres of fairly good road material, and Joe Glascock, on the southwest of 10, has several acres of sand and gravel, but the sand predominates, so that the deposit does not yield first-class road material. It is, however, about as good as the township affords.

Joel Tinsley, on the southwest quarter of section 7 (19 N., 6 W.), has an abundance of sand and gravel, but as a whole it is too fine for first-class road material. The sand is said to be good

for concrete work. The bank run material makes a fairly good road—one that beats a clay road out of sight. Jesse Brant, on the southeast quarter of section 8, and Charles Armentrout, on the northeast of 21 (19 N., 6 W.), each has several acres of sand and gravel. The sand is of good quality and there is some good gravel, which could be had by screening. H. S. Edwards, on the southwest quarter of section 5, has 5 or 6 feet of gravel to water, but little is known of how much there may be below water level. The material is of good quality. Gravel from the streams is used extensively for road building in this township, and is called good.

Jackson Township.

This township comprises township 18 north, ranges 6 and 7 west. Sugar Mill Creek flows southwesterly across its area. The suface is somewhat broken along the creek, but in general is undulating. Wallace, just south of the center, is the chief town. Good road material is not common.

Jonathan Cunningham, on the southeast quarter of section 26 (18 N., 7 W.), has an abundance of sand and gravel. The material is of good quality, but too fine for first-class road material. This deposit contains the best material in the neighborhood and supplies large quantities to the southwestern portion of the township, sending some into Parke County.

The Carter gravel pit, on the southeast quarter of section 13, is a large, shallow pit, with about 8 feet of medium road material. There are perhaps six acres in the deposit. It makes fairly good roads, but does not wear very well. Columbus Young, on section 12, has several acres of sand and gravel. Some portions of this deposit yield very good road material.

Jacob Bowman, on the southwest of 17 (18 N., 6 W.), has an abundance of good gravel, but it is under 4 to 6 feet of soil and clay, so that it is difficult to work. Much of the road from Wallace north to Hillsboro was built from the J. B. West bank, on the northwest of the northwest of section 6 (18 N., 6 W.), but this bank has not been in use for several years. There are some deposits of gravel about Wallace and at other places in the township, but none of much importance have been opened. Jackson Township uses considerable stream gravel.

MONTGOMERY COUNTY.

Area in square miles	508
Population in 1900	29,388
Miles of public roads	827
Miles of improved roads	450
Percentage of roads improved	54.4
Miles improved with gravel	450
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,500
Total original cost of improved roads	$675,000
Annual cost of repairs per mile on gravel roads 5 years old	$400
Miles of improved road (gravel) built in 1905	10
First improved roads built	1879
Proportion of improved roads built since 1895 (per cent.)	10
Satisfaction of farmers with investment in improved roads	Good
Authority	B. F. Carmen, County Auditor

Montgomery County, in the western part of Indiana, is bounded on the north by Tippecanoe County, on the west by Fountain and Parke counties, on the south by Parke and Putnam, and on the east by Hendricks, Boone and Clinton counties. The county is regular in form, extending through townships 17, 18, 19 and 20 north, and ranges 3, 4, 5 and the east half of 6 west.

Sugar Creek, flowing southwesterly through the central portion of the county, drains the greater part into the Wabash. Coal Creek drains the northwestern portion, and Raccoon Creek the southern portions. There is considerable broken country along Sugar Creek, but in general the surface of the county is a gently undulating plain.

Gravel is widely distributed over Montgomery County. There are no great deposits, such as occur in the terraces of the Wabash, but there are large numbers of comparatively small deposits that may be kames or fragments of eskers. Deposits along the streams that may seem to be terraces are in many cases kames that the streams have disclosed and which are the chief source of the sand and gravel in the stream beds. There are many deposits of "water gravel," occupying channels or basins of various depths and covered with more or less soil and clay.

In the southern part of the county there are several outcrops of rock that would probably make valuable road material. Some quarries have been opened, but none were found in operation.

Sugar Creek Township.

This township is in the northeastern part of the county. There is considerable good gravel in the bed of Sugar Creek, which bounds the township for four or five miles on the southeast. E. Russell's gravel bank, on the northwest of the southeast of 34 (20 N., 3 W.), is a large pit in a deposit several acres in extent. As opened the gravel is only about 15 feet thick, but is thought to be much thicker. This pit yields good road material.

In the central portion of the township many pits have been opened in an old esker. William Fisher, on the northeast of the southwest of section 22; Benjamin Stitt, on the northwest of the northwest of 27; Wm. H. Marts, on the northeast of the northeast of 28; Marion Holloway, on the southwest of the northwest of 28; Wm. H. Marts, on the southwest of the northeast of 29, and Mrs. Corbin, on the southeast of the northeast of 29 (20 N., 3 W.), all have gravel pits in the esker, and each has an abundance of good road material. There is a deposit of water gravel on the west half of the northwest quarter of section 34 (20 N., 3 W.), known to be from 30 to 40 feet thick. Its area is not known. In quality the material seems to be good.

Mrs. Betty Bowers, on the northwest of 10, has a deposit of gravel that is 3 or 4 feet down to water, the depth below water level not being known. It is called good road material. Grant Gray, on the southwest of the southeast of section 7, has a large deposit of water gravel. There are from 6 to 8 feet of gravel to water and at least 20 feet below water level. This deposit is also said to yield good road material.

Madison Township.

This township is largely prairie land. Stingley's gravel pit, on the southwest of the northeast of section 11 (20 N., 4 W.), is in a deposit several acres in extent, and shows soil and clay 1 to 3 feet, gravel to water, 8 to 10 feet. The depth below water level is said to be 25 to 30 feet. The material is said to make good roads. Harry C. Shobe, on the northwest of the northwest of section 1, has considerable gravel of a medium quality. The Harrigan pit, on the northwest of the southwest of 17, is in a large deposit, 25 to 30 acres in extent, but the quality is only fair.

The Elijah Bowers pit, on the north half of section 13; that of James Gayley, on the southeast of the southeast of 15, and one belonging to James Booth, on the southwest of the southwest of 22 (20 N., 4 W.), have all been worked down to water level. There seems to be an abundance of good gravel in this region, but no one seems willing to undertake the getting of it out by machinery from below water level.

Coal Creek Township.

This is a large township, six miles north and south by nine miles east and west. Sand and gravel are well distributed, Thomas Cook's bank, on the northwest of section 14 (20 N., 5 W.), is in quite a large deposit, many acres in extent. As opened, this pit shows—

Section of the Cook Bank.

	Feet.
1. Soil and clay	3 to 4
2. Fine sand	3
3. Good gravel	15 to 18

There are a few boulders in this deposit, but the material is of excellent quality, makes good roads and wears well. Thomas Grantham, on the southeast of the southeast of section 3, has a gravel pit in the top of a hill. There are about 18 feet of gravel exposed in the pit, but it is thought to run much deeper. The deposit seems to be four or five acres in extent. It is called good gravel. On the northeast of the southeast of 9 (20 N., 5 W.), in the edge of the town of New Richmond, Mr. H. K. Lee has taken out a great quantity of water gravel. The pit shows 1 to 4 feet of black soil and clay, then 20 feet of gravel in water. The material is rather fine, but is said to make good roads. It is at present extensively used in repairing roads in the vicinity. James Tribby, from his pit on the northeast of 10, furnishes gravel to the railway and to the township.

Clarkson's pit, on the northwest of the southwest of 6 (20 N., 5 W.), is in a deposit of several acres in extent. As opened, it shows—

	Feet.
1. Soil and clay	1 to 3
2. Gravel exposed	15

There is some fine sand and considerable good road material.

The Meharry pit, on the southwest of section 2, and Arthur Evans's pit on the southeast of section 3 (20 N., 6 W.), are in the banks and bed of Coal Creek. They find a good gravel in each locality. Some people in this region consider the stream gravel the best road material.

The Cottrell pit, on the southwest of the southwest of section 15 (20 N., 6 W.), is in water gravel, 20 to 30 feet thick. There are at least three acres of gravel. On the northwest of section 26 there is a great hill of sand and gravel owned by Mr. Lawson. The pit has not been in use for some years. Gravel has been furnished to the township from the following localities: The Dewey place, on the northeast of the southeast of section 2 (20 N., 5 W.); the Beach place, on the southeast of the northwest of 11; the Crane place, on the southeast of the southwest of 23, and the Homell place, on the northeast of the northeast of 13 (20 N., 6 W.); also from the southeast of the southwest of 35, the southeast of the southwest of 22, and the northwest of the southwest of 25, the northeast of the northwest of 29, the northwest of the southeast of 36 (20 N., 5 W.), and from several other tracts of land.

Wayne Township.

Sand and gravel are well distributed over this township, but there are no large deposits, and the gravel is generally only a medium quality of road material. The following named persons have furnished gravel to the township: James Rivers, from the southwest quarter of section 3; Howard Vaughn, from the southeast of 12; James Switzer, from the northwest of the southwest of 32, and Philip Biddle, from the north half of the northwest of 9 (19 N., 5 W.); F. M. Harvey, from the south half of the northeast quarter of section 22; W. H. Munn, from the southeast of 26; Meda Ball, from the southeast of 31 (19 N., 6 W.), and others at different times. In this township but very little creek gravel is used.

Ripley Township.

This township is bounded on the southeast by Sugar Creek, and has considerable broken land along that stream. There is quite a quantity of good gravel within its area.

J. W. Taylor, on the northwest of the northwest of section 8, and Francis Thompson, on the southwest of the southeast of 4 (18 N., 5 W.), have great quantities of excellent road material. Ulysses Wright, on the east half of the east half of 30, has also an abundance of good road material.

James R. Gilkey, on the east half of the northwest quarter of 17, has 30 to 40 acres of good sand and gravel, and there is an abundance of good gravel on the north half of the southwest of 19 and on the northwest of 16 (18 N., 5 W.). This deposit is in the bluff of a little creek and is of considerable depth. Mr. Gilkey says that it is at least 40 feet thick. There is considerable cemented gravel in this deposit. The sand found in it is especially good for concrete work.

Thomas A. Herron, on the southwest of the northeast of section 10; Hannah Dochterman, on the south half of the northwest of 10; N. R. Meyers, on the northeast of 15; F. M. Holman, on the southeast of 35, and Benjamin P. Earl, on the northwest of the northwest of 36 (18 N., 6 W.), each has an abundance of good road material. John Ammerman, on the northeast of the northeast of 26, has a large pit in a deposit of only fair quality. There are only 8 to 10 feet of gravel, and the 3 to 5 feet of soil covering it makes the working difficult.

Union Township.

This township is twelve miles long from north to south and about nine miles wide. The city of Crawfordsville is near its center. The township is well supplied with gravel.

There is a large deposit of sand and gravel near the center of section 28 (19 N., 4 W.). The Vandalia Railway Company opened a large pit in this deposit alongside their road. G. W. Stafford opened a pit along the wagon-road to the east, and William Stitt has two pits in the same deposit which must be at least 40 acres in extent. As exposed in the pits, this gravel is only 18 to 20 feet thick, but it is known to be considerably thicker. This material is of good quality, makes a good road and wears well.

J. R. Carpenter, on the west half of the northwest of 22 (19 N., 4 W.), has 15 to 20 acres of excellent road material. It has been worked to a depth of 30 feet. On the south part of section

14 there is a great body of sand, with some good gravel. The Vandalia people once opened a pit on this section. Al. B. Smith, George Downing and Ella Flannigan each have pits in this deposit. The material is of good quality, but is mainly sand rather than gravel, and should be screened before using.

J. J. Dauter, on section 36; John Swank, on the east half of the northwest of 23; William Loffland, on the southeast of 7, and James Butcher, on section 5 (19 N., 4 W.), furnished good gravel to the township. Large numbers of gravel deposits in the north part of Union Township seem to be kames or deposits of somewhat similar origin. On sections 1 and 12 (18 N., 4 W.), there is a large body of sand and gravel. Jehu Chadwick, on the southwest quarter of 1; Wm. Stafford, on the southeast of 12, and Otis Stafford, on the northeast of 12 (18 N., 4 W.), have pits in this deposit. The gravel is only 15 to 20 feet thick to shale. There is some fine sand in these pits, but good gravel largely predominates.

Charles Smith, near the center of section 3 (18 N., 4 W.), furnishes large quantities of gravel to the township. Henry Davidson, on the east half of the northeast of 33, has a large pit. It has furnished large quantities of gravel for the last eight years. The deposit is perhaps four acres in extent, and from 10 to 12 feet thick.

J. C. Walters, on the north half of the southwest quarter of 27, has quite a large pit worked down 8 or 10 feet to water. A little to one side in the bed of a small stream a deposit of water gravel was recently discovered. A scoop was installed and gravel is being taken out to a depth of 20 feet. The material seems rather fine for road purposes. There is some medium gravel on the southeast of the southwest of 32, and on the northwest of the southwest of 36 (18 N., 4 W.). Considerable quantities of gravel are taken from the bed of Sugar Creek for use in improving roads. During the year 1904 Union Township paid over 60 different persons for gravel for road improvement.

Franklin Township.

This is township 19 north. Darlington is the chief town. Charles Welvier, on the north half of section 8 (19 N., 3 W.), near the west line of Darlington, has a quantity of good sand and

gravel. As opened, there are about 20 feet of gravel exposed. The deposit probably contains several acres. Clayton Cox, on the southwest of the southwest of 4, has a pit that seems to be about worked out. There may be some gravel below water level.

Miller's pit, on the northwest of 23, is in quite an extensive deposit of very good road material. Several miles of good road have been made from this pit. Mount's pit, on the east half of the southwest of 27, is in a large deposit of fairly good road material.

The Elmore pit on the west half of the northeast quarter of section 33 (19 N., 3 W.), is in a deposit of gravel that has an extent of about three acres. As opened the gravel is about 12 feet thick. The material shows considerable sand, a few rotten stones and some small boulders. It makes a fairly good road but does not wear very well.

On the west half of the northwest quarter of section 34 (19 N., 3 W.), are two gravel hills known as the Castor Mounds. The larger mound is somewhat conical in shape, about 40 feet high and 250 feet in diameter at the base. It seems to be composed of sand and gravel. On its slopes there are several great granite boulders. Just east is another mound or hill of wider area but not more than 25 to 30 feet high. It also seems to be composed of sand and gravel and there are many large boulders upon its slopes.

Walnut Township.

This is township 18 north, and is not very well supplied with gravel. W. W. Ward has five or six acres of gravel on the northwest quarter of the southeast of section 7 (18 N., 3 W.). The pit as opened shows:

	Feet.
1. Soil and clay	3 to 5
2. Sand and gravel to shale	12 to 14

The sand is good for plastering and cement work and considerable good road material is present. The Fletcher pit, on the east half of the southwest of 7 and the Lockridge pit on the east half of the southeast of 8, yield an abundance of gravel about the same in quality as that from Ward's pit.

The Bruce pit is on the southeast of the northwest of 14 (18 N., 3 W.). The deposit seems to be several acres in extent and, as

opened, the gravel is about 12 feet thick. There is some water gravel in an adjoining creek bed. In each case the quality seems good, but the material is too fine for good road material, and should be screened before being used. William Miller's pit, on the southwest of section 12 (18 N., 3 W.), as opened, shows:

	Feet.
1. Soil and clay	3 to 5
2. Good gravel to water	3 to 10
3. As tested under water	20

It is not thought to be a very extensive bed. The material contains too much sand for first-class road material, and if used should be screened.

There is some gravel on the northwest quarter of section 24, on the southeast of 12 (18 N., 3 W.), and at other localities in the township. On the southwest of the southwest of 5 John Ward has a deposit of water gravel under from two to five feet of soil and clay. It is thought to be several acres in extent.

Clark Township.

This township is in the southeast portion of the county, and is township 17 north. Ladoga is the chief town. At different places along Raccoon Creek there are extensive deposits of sand and gravel. On the northwest of section 2 (17 N., 3 W.) there is a deposit in which Mr. Standiford has a pit and on the northeast of the same section Mr. Tipton has another. Nothing definite is known as to the extent or depth of this deposit. It must be at least 40 to 50 acres in area and as opened shows about 10 feet of gravel to water. Sand predominates in this deposit, but there is some good road material present.

On the north half of section 3 (17 N., 3 W.) there is an extensive gravel pit opened by the railway on Dan Myers' land. F. W. Baldwin's pit on the west half of the northeast of 9 is also in the valley of Raccoon Creek. In each of these pits the material is abundant and of good quality, but contains too much sand for first-class road material, and should, therefore, be screened before using.

Sam Otterman, on the west half of the northeast of 22, furnishes considerable gravel to the township, which is said to make fairly good roads.

Nathan Hulett, on the northeast of 34, has a large deposit of water gravel. Nothing very definite is known as to its area or depth, but it is thought to be extensive. It is called good material. This township gets some material from Scott Township on the west.

Scott Township.

On the southeast of the southwest of section 13 (17 N., 4 W.) James Knox has perhaps 20 acres of gravel. As opened, the gravel is about 12 feet thick, but is known to run much deeper. On the northwest of the northeast of 24, James Danewood has a large deposit of gravel, much like that of Mr. Knox, on the other side of the creek. In each case the gravel is of good quality.

Albert Goodbar has plenty of gravel on the southwest of the northeast of 27, but the bank has not been opened for several years. David Britt, on the north half of section 26, has an abundance of both bank gravel and stream gravel of good quality. J. W. Foster, on the northwest of 33, also has quantities of stream gravel. On the northeast of the northwest of 5 (17 N., 4 W.) there is a shallow deposit of water gravel about 12 feet deep and of good quality, but rather fine. Good road material is rather scanty in the western part of Scott Township.

Brown Township.

This township is in the southwestern portion of the county. It is drained by Indian Creek and several branches of Raccoon Creek. There is considerable broken land along the streams. The Township is not very well supplied with gravel.

On the northwest of 7 (17 N., 5 W.) Mr. R. Kirkendall has an abundance of good road material. On the southwest of the northwest of 9 Lee Mottens has some good gravel, and Walter Grimes, on the northeast of the southeast of 35, has also quantities of good gravel. The Gorman pit on the west half of the northeast of 15 supplies only a medium grade of gravel. The township gets some gravel from pits to the south in Putnam County. It also uses considerable stream gravel, which many think is very good.

Owing to the scarcity of gravel, Brown Township has tried some stone for roads. On the north half of the northeast of 18 (17 N., 5 W.) a limestone quarry was opened and a crusher installed.

Stone was broken and some road was built. The road is not satisfactory but the fault seems to be in the construction rather than in the material used. The crusher did not run the second year. In the quarry there are several thin layers of hard limestone, but much the greater part is soft, clayey limestone. Doubtless each rock would make a fairly good road, but the harder would wear the better.

On the southeast of the southeast of 34 (17 N., 6 W.) there is another quarry, on the land of J. E. Oldshoe. It was opened and operated for several years by a Terre Haute company. The material produced was used in making roads in the Terre Haute Cemetery. It was also used in South Bend, in New Market, in Waveland, Rockville and other places, giving good satisfaction. The quarry has a face, as opened, of from 25 to 30 feet. There are several different strata that vary in texture and thickness, and the strata vary in different parts of the quarry. A series of specimens designed to represent the average of the quarry were sent to the Laboratory of the U. S. Department of Agriculture for various tests, the results of the physical tests being as follows:

*Results of Physical Tests of Mitchell Limestone from Oldshoe Quarry near Waveland, Montgomery County.**

Specific gravity	2.7	French coefficient of wear	10.2
Weight per cu. ft. (lbs.)	165.3	Hardness	—5.2
Water absorbed per cu. ft. (lbs.)	1.35	Toughness	5
Per cent of wear	3.9	Cementing value—Dry	23
		Wet	43

A chemical analysis of the specimens was made at the same laboratory, with the following results:

Chemical Analysis of Mitchell Limestone from Oldshoe Quarry, near Waveland, Montgomery County.

	Per cent.
Silica (SiO_2)	1.00
Iron oxide (Fe_2O_3)	.50
Lime (CaO)	54.10
Insoluble in hydrochloric acid	2.17
Loss on ignition	42.06
Total	99.83

The quarry was not in operation during the season of 1905.

*For standard of comparison see p. 79.

VERMILLION COUNTY.

Area in square miles	255
Population in 1900	15,252
Miles of public roads	800
Miles of improved roads	300
Percentage of roads improved	37.5
Miles improved with gravel	300
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,800
Total original cost of improved roads	$540,000
Annual cost of repairs per mile on gravel roads 5 years old	$50
Miles improved roads (gravel) built in 1905	20
Proportion of improved roads built since 1895 (per cent.)	20
Satisfaction of farmers with investment in improved roads	Good
Authority	H. T. Payne, County Auditor

Vermillion County is in the central western part of Indiana. It is bounded on the north by Warren County, on the west by Illinois, on the south by Vigo County, and on the east by Parke and Fountain counties, from which it is separated by the Wabash River. The county is about 35 miles long from north to south and has an average width of about seven miles. It consists of extensive flood plains along the Wabash, a wide terrace of sand and gravel and the uplands on the west. The uplands rise to an elevation of about 200 feet above the river. The county is drained by Spring and Jordan creeks, Big and Little Vermillion rivers, and Raccoon, Norton's, Feather and Brouilett's creeks, all flowing into the Wabash River.

The county is divided into five civil townships, viz., Highland Township in the north part, with about 60 miles of gravel road; Eugene Township, with 40 miles of improved roads; Vermillion Township, with 40 miles of gravel road; Helt Township, with 100 miles of gravel road, and Clinton Township, with about 50 miles of improved roads. The gravel deposits of the county are found mainly in the river terraces and along the larger streams.

Northern Portion of the County.

In the northern part of the county a pit has been opened on the Talbot land, in the southeast quarter of the southeast quarter of section 4 (19 N., 9 W.), on the bank of Spring Creek. The deposit seems to be a continuation of beds in the southern part

of Warren County. There are three to eight feet of soil and sand, then 12 to 15 feet of gravel in the pit. Wells in the neighborhood show that the bed of gravel is at least 30 to 40 feet thick. There are several hundred acres of sand and gravel in this region, a large portion of which seems to be gravel. The gravel exposed in the pit was of the first quality.

The next gravel pit south is on the northeast quarter of the southeast quarter of 21 (19 N., 9 W.), on Jacob Doring's land. The deposit is only 3 or 4 acres in extent and is from 15 to 18 feet thick, as shown in the pit. It yields good road material. Gravel from this pit goes north and south and several miles to the west.

Philander Goff has water gravel on the southeast quarter of section 7 (19 N., 9 W.), the gravel being about 10 feet thick to clay. E. Shute, northwest quarter of the southwest quarter of section 16; J. R. Dunlap, southwest quarter of the northwest quarter of section 16, and David Talbot, on the southwest quarter of section 4 (19 N., 9 W.), each have water gravel. The material makes fairly good road, but is rather fine grained.

Considerable gravel for road building has been taken from Coal Creek, a branch of the Big Vermillion. It is said to make a good road, but does not pack as well as that from the pits.

The Hicks gravel pit, on the southwest quarter of the southwest quarter of section 28 (19 N., 9 W.), near Perrysville, yields good gravel and is in a deposit which appears to be several acres in extent. There are also gravel pits on the northeast quarter of section 32, and on section 33, with an abundance of gravel. These pits are near the head of a broad terrace that extends for several miles toward the south, practically to Newport, on the Little Vermillion River.

Buzzard's gravel pit, on the northeast quarter of the southwest quarter of section 5 (18 N., 9 W.), shows 2 or 3 feet of soil and 8 or 10 feet of gravel. The deposit runs much deeper, as shown by wells in the neighborhood. This pit furnishes good road material. There are no gravel pits along the terrace between Buzzard's pit and Eugene, but gravel is abundant, and many miles of road have been improved with gravel from the sides of the road. There is some gravel on James Fleming's place, on section 20 (18 N., 10 W.), in the banks of the Big Vermillion, and there are several

other small deposits along this river. There is also some good gravel in the bed of the stream, but the quantity is small as compared with that in the terrace.

Dr. E. A. Flaugher has a gravel pit on the northeast quarter of the southeast quarter of section 30 (18 N., 9 W.), from which three or four miles of road have been improved.

Vicinity of Eugene and Cayuga.

There is an abundance of gravel about Eugene and Cayuga, especially on the northeast quarter of section 31 (18 N., 9 W), near Eugene, and on the northeast quarter of section 6 and the southeast quarter of section 5 (17 N., 9 W.), south of Cayuga. All of these contain good gravel. In Cayuga, alongside the Clover Leaf Railway, there is a pit. Between Cayuga and Newport, or between the Little and Big Vermillion rivers, there is a broad gravel terrace. Gravel occurs in the banks and bed of the creek on the northwest quarter of the southeast quarter of section 8, and there is a pit near the north line of the northeast quarter of section 17 (17 N., 9 W.). W. H. Dallas has a pit on the northwest quarter of section 16 and Joe Morehead one on the east side of the railway on section 26 (17 N., 9 W.). William Coffa and others have also gravel pits on section 28 of the same township.

Newport, on section 26 (17 N., 9 W.), is underlain with gravel. West of Newport, in the bluffs of Little Vermillion River, on the northwest quarter of section 30, Arthur Betson has an abundance of good gravel. Isaac N. Sager also has a pit on section 31, and Mr. Skidmore has one on the southeast quarter of the northeast quarter of section 29 (17 N., 9 W.). From Newport south to Hillsdale there is practically no gravel along the river, as the flood plain reaches the bluff, cutting out the terrace.

Southern Portion of County.

The Highland gravel pit, on the southeast quarter of section 27 (16 N., 9 W.), and the Alta gravel pit, on the southwest quarter of section 2 (15 N., 9 W.), furnish a good quality of gravel, much of which goes to Dana and other points in the western part of the county. The James pit and Strangs pit, in the central part of section 8 (15 N., 9 W.), on Norton's Creek, yield an abundance

of good gravel. From Alta southward to the county line the terrace is well developed and gravel and sand are abundant. A. L. Mack, on the southeast quarter of section 15 and the northeast quarter of section 22 (15 N., 9 W.), has plenty of good gravel, the deposit being supposed to be at least 90 feet thick. Mr. Stutzman has an extensive gravel pit on the north half of section 23. There are also two pits at Summit Grove, section 26 (15 N., 9 W.), owned by Albert and Charles Miller. The gravel about Summit Grove is especially good for road purposes. It is of good quality and large quantities are composed of grains of uniform size, like beans, and all solid, mainly of granite with some limestone.

John Strain has an extensive sand pit on the north half of section 34 (15 N., 9 W.). The material is especially fine, being nearly pure quartz. There is a gravel pit about the center of section 10 (14 N., 9 W.). In this deposit there is considerable cemented gravel.

The town of Clinton is largely underlain with gravel, and it also is abundant in sections 21, 22, 27 and 34 (14 N., 9 W.). Pits have been opened on the Whitcomb place, section 27, and on the Wm. Morley place, section 34. In general the gravel is of good quality and practically unlimited in quantity. There is some gravel along the bluffs of Brouilett's Creek. The Robertson bank, on the southwest quarter of section 11, and Shew's bank, on the northwest quarter of section 18 (14 N., 9 W.); Stafford's pit, on the southeast quarter of section 15 (14 N., 10 W.), and others furnish a medium quality of gravel, but it is not as abundant as on the terrace farther east.

The roads in the western part of Vermillion County have been built partly from local bank gravel, partly from stream gravel, but largely of material from pits on the terrace. Gideon Jackson has a gravel pit on the northeast quarter of section 15; Benj. Jones one on the northwest quarter of section 11, and J. L. Smith one on the west half of the northeast quarter of section 15 (14 N., 10 W.).

Some roads have been built of slag from the old Indiana blast furnace on the southwest quarter of section 23 (14 N., 10 W.). The slag as a foundation was covered with gravel. Considerable stream gravel is also used for improving roads in the southwestern portion of the county.

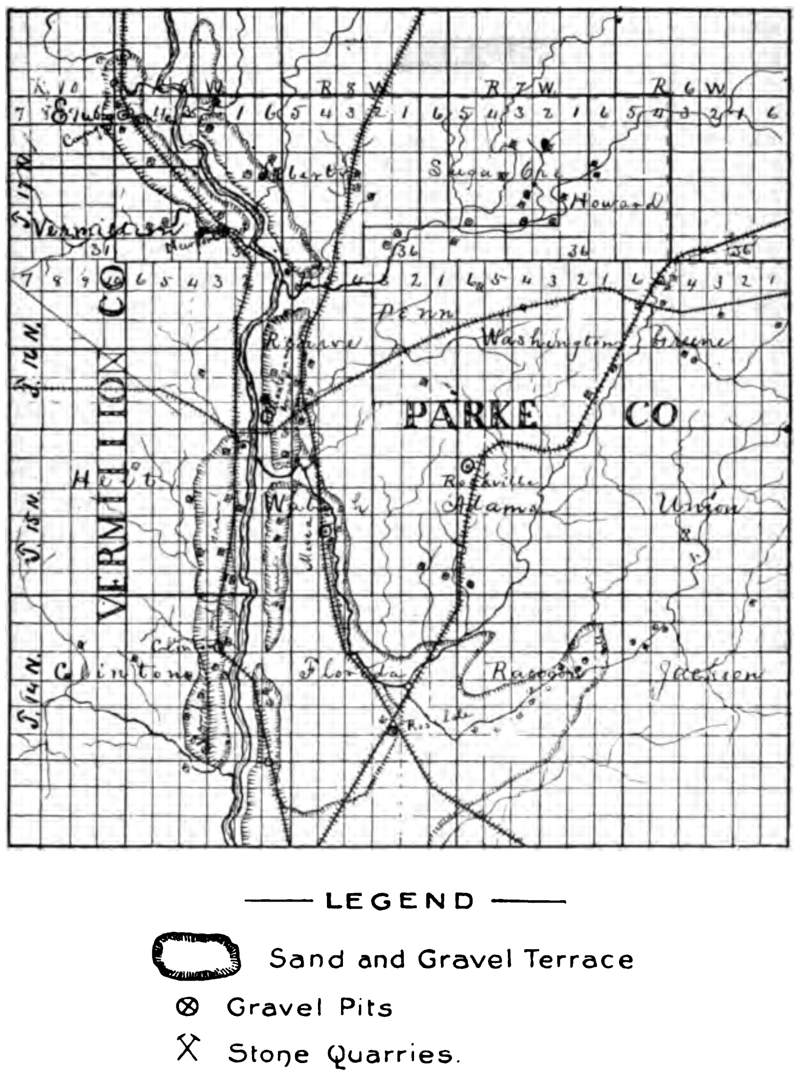

Fig. 42. Illustrating the distribution of road materials in Vermillion and Parke counties.

PARKE COUNTY.

Area in square miles	453
Population in 1900	23,000
Miles of public roads	1,200
Miles of improved roads	600
Percentage of roads improved	50
Miles improved with gravel	580
Miles improved with crushed stone	20
Average original cost of gravel roads per mile	$1,500
Average original cost of stone roads per mile	$2,000
Total original cost of improved roads	$910,000
Annual cost of repairs per mile on gravel roads 5 years old	$40
Annual cost of repairs per mile on stone roads 5 years old	$30
Miles of improved road (gravel) built in 1905	50
First improved roads built	1867
Proportion of improved roads built since 1895 (per cent.)	50
Satisfaction of farmers with investment in improved roads	Good
Authority	Henry Grubb, County Auditor

Parke County is bounded on the north by Montgomery and Fountain counties, on the west by Vermillion County, from which it is separated by the Wabash River, on the south by Vigo and Clay Counties, and on the east by Putnam and Montgomery counties. The surface varies in elevation from 474 to 800 feet above tide. It is drained by Sugar Creek and Big Raccoon Creek, with its branches, Little Raccoon, Iron and Leatherwood creeks. The flood plain and terrace are from 1 to 2 miles wide along the Wabash River, and there is considerable flood plain and terrace in the valley of the Big Raccoon. Along these streams there is much broken country and many rock exposures. There is an abundance of sand and gravel in the terraces along the river and in the valley of the Raccoon, but over much of the county gravel is wanting.

Liberty Township.

This township is in the northwest portion of the county, bordering on the river. Coal Creek from Fountain County flows across sections 1, 2 and 3 (17 N., 9 W.), in the extreme northwest of the township. Wabash Mill Creek flows across the township a little west of the center and Rush Creek drains the central portion. Lodi, on Coal Creek, is situated on a ridge of gravel in section 2, and there is a large deposit owned by D. Shirk on section

3, next to the river. There is here at least 30 to 40 acres of gravel, some of it 40 feet thick to water level. From Lodi southeasterly to Howard, on the southwest quarter of section 18 (17 N., 8 W.), there is an abundance of sand with occasional deposits of gravel, as at Miller's place, northwest quarter of section 12, and Elijah Lewman's place, on the southeast quarter of the southeast quarter of section 13 (17 N., 9 W.). About Lodi and in Lewman's pit the gravel is of excellent quality. Nothing definite is known as to the extent of the deposit at Lewman's. It seems to be a gravel hill surrounded and partly covered with dune sand.

The Leonard bank, the Picard bank and the Church bank, on the northeast quarter of section 18 (17 N., 8 W.) are near Howard, along Wabash Mill Creek. David Commons has two banks, one on the west half of the southeast quarter of section 15, the other on the west half of the northeast quarter of section 22 (17 N., 8 W.), both in the valley of Rush Creek. The gravel is of good quality but not as abundant as about Lodi and Howard.

The east part of the township gets gravel from the Towell bank, in Fountain County, and from the Wolf and Millikan banks, in Penn Township, Parke County. Gravel from the beds of the larger streams is sometimes used in road building, but it is not considered as good as bank gravel. There is some gravel in section 32 (17 N., 8 W.), but in general it is covered deep with boulder clay and can be worked only along the outcrop.

Reserve Township.

This township borders the Wabash River. Montezuma, in the southwestern part, is the chief town. Sugar Creek flows across the northwestern part of the township and Leatherwood across the southeastern portion. The terrace in this township is about 1½ miles wide and deeper than the deepest wells. On the north half of section 6 (16 N., 8 W.) there is some gravel, but it is under considerable clay and is not considered good road material. Near West Union, on the south half of section 7, Mr. Linebarger has opened several gravel pits along the terrace. He claims to have 300 or more acres of sand and gravel, and that he can get good gravel wherever it is convenient to open a pit. Nothing is known about the depth of this deposit. The gravel is of good quality, but

is rather fine and is not considered as good road material as that found farther south in the same terrace.

The Adams pit, on section 19, and the Vestel pit, on the southwest quarter of section 30 (16 N., 8 W.), show abundance of gravel about like that in the Linebarger pits. The C., H. & D. Railway has also a large gravel pit on the west half of section 31. The gravel as exposed in the pit is about 30 feet deep and of good quality. In the north part of Montezuma, on the southwest quarter of the southeast quarter of section 26 (16 N., 9 W.), there is an extensive pit, which yields excellent road material, rather coarser than from other pits in the township. Several other pits have been opened along the terrace. East of this terrace there is practically no gravel.

Wabash Township.

This township corresponds to 15 north, ranges 8 and 9 west. It includes a wide terrace along the Wabash River and considerable terrace land along the Big Raccoon as well. The Pratt pit, on the northeast quarter of the northeast quarter of section 1 (15 N., 9 W.), near the north line of the township, shows good gravel and pits on the northeast quarter of section 12 show fairly good gravel, but farther south the terrace is mainly sand with but little trace of gravel. On the northwest quarter of the northwest quarter of section 7 (15 N., 8 W.), there is plenty of sand or fine gravel, but it does not pack well. As one man says, "it is creepy." George Ussleman, Duncan Puett, Henry Underwood, Peter Pence and others have sand or gravel pits along the terrace south of Armiesburg.

About Mecca, on section 20 (15 N., 8 W.), in the valley of Big Raccoon, there are several pits furnishing good gravel. Among them are the Hixon pit, the Montgomery pit and the Dee pit. North of Mecca there are several pits along the railway, and an abundance of fairly good gravel. South of Mecca, up the creek, there is an abundance of good sand, but no really good road material.

Florida Township.

This township corresponds to township 14 north, ranges 8 and part of 9 west. At Lyford, sections 12 and 13 (14 N., 9 W.), the flood plain reaches the bluff cutting out the terrace. South of

Lyford, on section 23, the "Big Gravel Terrace" begins. On the east half of section 23 (14 N., 9 W.) is located the famous Lyford gravel pit. In the north end of this pit there is a section of fine sand, then a section some 300 feet long of fairly good gravel, in which there are fragments of coal, pieces of shale and sandstone, and large pieces of boulder clay, all apparently local material showing little water action. Mingled with these are quartz sand and granite pebbles, evidently of foreign origin. Beyond this there is an abundance of gravel of excellent quality. There are a few large boulders and some fine sand, but in general the deposit is good road material. There are from 40 to 50 feet of gravel down to water level.

In the southwest part of Florida Township there is an area of about three sections of gravel. There is some gravel and considerable good sand about Rosedale, on section 27 (14 N., 8 W.), but little good road material. There is good sand along the valley of Raccoon Creek, but the only good road material in the township seems to be in the Lyford terrace.

Raccoon Township.

This township, lying east of Florida Township, is wholly in the valley of Big Raccoon Creek. It consists of flood plain, terrace and upland, with considerable coal and shale. Good gravel is abundant. O. A. Cole has a pit on the southwest quarter of section 12; J. N. Miller on the north half of section 14, and J. R. Johns on the southeast quarter of section 15; all in township 14 north, range 7 west. On section 15 the Chicago and Southeastern Railway has a gravel pit in which there are 8 to 10 feet of gravel above ground-water. The quality seems good but the material is rather fine for first-class road material. There is good gravel on sections 21, 28, 29 and 30 (14 N., 7 W.). Not very much is known about the depth of this deposit, but a well drilled in the valley near Rosedale shows 80 feet of sand and gravel to bed rock.

Jackson Township.

This township is in the southeast portion of the county. In the bed and banks of Raccoon Creek there is considerable sand and gravel. Johnson's banks, one on the northeast quarter of section 8

(14 N., 6 W.), and another on the southeast quarter of the northeast quarter of section 7 (14 N., 6 W.), show fairly good gravel, but the deposits are not large, perhaps five or six acres, with 6 to 8 feet of gravel to water level.

In Raccoon Creek, at Mansfield, on the northwest quarter of section 8 (14 N., 6 W.), there is a great mass of good gravel known to be 20 to 25 feet thick. N. Derman, on the southeast quarter of section 7 (14 N., 6 W.), has about 20 acres of good material, 6 to 8 feet thick, situated along the creek bed. Other stream beds furnish some gravel. Elijah White, on the northeast quarter of section 2 (14 N., 6 W.); Milton Murphy and Green Taylor, a little south of White's place, have some good road material. Aside from the stream deposits, Jackson Township is not well supplied with road material.

Union Township.

This is township 15 north, range 6 west. Raccoon Creek flows southerly through the central part of the township. Stout's bank, on the southwest quarter of the southeast quarter of section 10, is several acres in extent and shows 10 to 12 feet of good gravel for road building. About 10 miles of road have been improved from this bank.

F. Nelson and J. S. Shalley, on section 13, have each furnished some gravel to the township. Considerable material has also been taken from the bed of Raccoon Creek and of other streams for use in improving roads.

There are several outcrops of good rock in the township. The lack of good gravel has led to the building of stone roads. John Wilson has a quarry on the southwest quarter of section 21, and William Kinsey one on the southeast quarter of section 28. In the Wilson quarry there are two strata of limestone, one white, about 8 feet thick, the other blue, about 6 feet thick; both hard, the blue stone having the more uniform texture. In the Kinsey quarry the stone appears to be more uniform in color but seems to be softer than that in the Wilson quarry. The rock from these quarries would apparently make a good road material, but the roads made of it are not satisfactory. This is not because the stone was not good, but because the roads were not well graded

and drained, mainly because the township was not able to pay the price of a good road. The poor stone road is, however, very much better than a clay road.

Adams Township.

This township lies between Union and Wabash townships. It is drained by Little Raccoon, Williams and Sunderland creeks. Rockville is the chief town. The improved roads have been built largely of creek gravel. Of the ten persons furnishing gravel to the township in 1904, seven furnished stream gravel. James Ryan has 8 to 10 acres of fairly good gravel on the east half of section 36 (15 N., 8 W.). It is from 12 to 15 feet deep, but rather fine for the best of road material. Guy Alden has some gravel on section 26 (15 N., 8 W.), and Nelson Thompson has a good pit on section 31 (15 N., 7 W.). The larger part of the stream gravel comes from the bed of Little Raccoon Creek.

Penn Township.

This corresponds to township 16 north, range 8 west. Sugar Creek flows across the northwestern corner and Leatherwood flows from east to west across the central portion of the township. Bloomingdale is the chief town.

The Rauch gravel pit, on the northeast quarter of section 35; the Wolf pit, on the southwest quarter of section 25; the Rice pit, on the southeast quarter of section 29, and the Russell pit, on the northwest quarter of section 32, all furnish fairly good road material, and the supply is abundant, but it was impossible to make any definite estimate of the area and depth of gravel in any case. Considerable gravel is taken from the bed of Sugar Creek, and from the bed and banks of Leatherwood Creek, for road improvement. The Kelly gravel pit, on the northeast quarter of section 26, also supplies some good road material.

Washington Township.

This corresponds to township 16 north, range 7 west. Marshall is the chief town. Little Raccoon Creek flows across the southwestern corner of its area. There is no workable bank gravel in

the township. C. K. Huff has some material in the bed and banks of Roaring Creek in section 6.

W. H. Barnes, on the southeast quarter of section 24, and J. C. Buchanan, on the southeast quarter of section 26, get some good gravel from the banks and bed of Little Raccoon Creek. The township gets gravel from John Lusk's bank, in Sugar Creek Township, and some from Howard and Greene townships.

Greene Township.

This is township 16 north, range 6 west. Little Raccoon Creek flows westerly across the northern part of its area, and a creek from Montgomery County comes in from the northeast. Along this creek, in the southeast quarter of section 5 and the northwest quarter of section 8, there is a terrace of sand and gravel. William Jarvis has a gravel pit in each end of this deposit. This deposit has an area of 50 or 60 acres, and varies from 10 to 12 feet to water level. Above the gravel is a soil and clay stripping from 16 to 36 inches in thickness. It is called good road material.

There is some terrace on section 21 along the east fork of Little Raccoon Creek. The Sulton bank and the Peyton bank are in this deposit. It has an area of 25 to 30 acres, and there is 10 to 12 feet of gravel above ground-water. About eight miles of road have been improved from these banks. The material from this deposit makes a good road. Considerable gravel is also taken from the bed and banks of Little Raccoon Creek for road improvement.

Howard Township.

This township borders on Fountain and Montgomery counties. Sugar Creek flows southwesterly across the northern part of its area.

Henry Windle and Sherman Delph each have an abundance of gravel along the banks of Sugar Creek in the western part of the township. William Clore and Henry Litsey, in the southwestern part of the township, furnish good gravel to Howard and Washington townships. Johnson Clore has 12 to 15 acres of good gravel on the banks of Sugar Creek. The gravel is from 30 to 40 feet thick and is easily accessible.

Sugar Creek Township.

Brush Creek, Sugar Mill Creek and Green Creek flow southerly across the area of this township. John Lusk has quantities of good gravel on sections 22, 23, 26 and 27 (17 N., 7 W.) along the bluffs and second bottoms of Brush and Sugar creeks. Paul Lungen has an abundance of gravel on the north half of the southeast quarter of section 22, along Brush Creek. George Alexander, on the southeast quarter of section 16, has plenty of gravel. Luther Delph, on the west half of the southeast quarter of section 11, and Marion Harrison, in the west half of the southwest quarter of section 10 (17 N., 7 W.), both have large deposits of good gravel. Sugar Creek Township gets some gravel from Howard Township and some from Fountain County. In general the greater part of Parke County is well supplied with gravel.

VIGO COUNTY.

Area in square miles	402
Population in 1900	62,035
Miles of public roads	725
Miles of improved roads	220
Percentage of roads improved	30.3
Miles improved with gravel	220
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,414
Total original cost of improved roads	$311,187
Annual cost of repairs per mile on gravel roads 5 years old	$180
Miles of improved road (gravel) built in 1905	30
Miles of improved road (gravel) contracted for 1906	16
First improved roads built	1898
Satisfaction of farmers with investment in improved roads	Good
Authority	Jerome W. Denehie, County Auditor

Vigo County is situated on the western boundary of Indiana, and is bounded on the north by Parke and Vermillion counties, on the west by Illinois, on the south by Sullivan County, and on the east by Clay County. The Wabash River flows through the northern part of the county, forming its western boundary in township 10 north. The river valley in the county is four to five miles wide, and its flood plain is from one to four miles wide. The big terrace is on the eastern side of the river and is fully three miles wide. It rises from 60 to 80 feet above low water in

the north, diminishing toward the south to 15 or 20 feet near the north line of township 10 north. The uplands on either side rise 70 to 80 feet above the terrace.

The principal streams of the county are Spring, Otter, Lost, Honey and Prairie creeks on the east, flowing westerly into the Wabash. On the west in the extreme north is Brouilett's Creek, then Coal and Sugar creeks. There are immense quantities of sand and gravel in the valley of the Wabash. The wells drilled for oil show from 75 to 150 feet of sand and gravel to the bed of the old channel. Vigo County has a bed of sand and gravel 24 miles long and 4 miles wide, averaging 100 feet in thickness. Large portions of this mass are first-class road material.

Area West of the Wabash River.

West Terre Haute, on the southeast quarter of section 19 (12 N., 9 W.), and vicinity, is on a gravel terrace of about 400 acres in extent. The Big Four Railway Company has a gravel pit of about 50 acres on the west half of the northwest quarter of section 20, and the Vandalia Railway Company has a pit of about the same size, mainly on the east half of the northeast quarter of section 19 (12 N., 9 W.). In these pits the gravel has been worked down to water level some 15 to 20 feet, and large quantities have been taken out with dredge and pump from below water level. There is a large gravel pit on the west half of the southwest quarter of section 20, and 2 or 3 on the southeast quarter of section 19 (12 N., 9 W.). This is called good gravel. It is rather coarse in some places, containing many large stones up to 5 inches in diameter. There is also considerable fine sand. The larger pebbles are of different kinds of granite and of limestone, while the finer grains are mainly of quartz. Of 600 gravel stones examined, about 35 per cent. were limestone, the remainder were mainly of different kinds of granite, with a few fragments of geodes. The limestones are usually solid, but they go to pieces under a crushing power that would scarcely affect the granite.

The Vandalia Railway Company are opening a gravel pit on the southeast quarter of section 36 (12 N., 10 W.), where they have about 70 acres of sand and gravel shown to be more than 50 feet thick. The tests show a larger per cent. of sand at a depth of

50 feet than was found nearer the surface. On sections 11, 15, 16 and 21 (11 N., 10 W.), in the southern part of Sugar Creek Township, there are at least 200 acres of gravel from 20 to 30 feet thick. There are no large pits, but gravel has been taken out at 8 or 10 different localities for making and repairing roads. The material is finer than that about West Terre Haute, but it packs well and makes a good road.

There is gravel near the road on the southeast of the northwest of section 17; on the Broadhurst place, north half of the southwest quarter of section 8, and on the Barbour place, on the southeast quarter of section 5 (12 N., 9 W.). These deposits do not seem to be very extensive. There is some gravel along the valley of Sugar Creek, as on the southeast quarter of the northeast quarter of section 23, and on the northwest quarter of the southeast quarter of section 16 (12 N., 10 W.). There is also gravel on the west half of section 31 (12 N., 9 W.).

From section 8 (12 N., 9 W.) northerly along the river, the only deposit of workable gravel found was in the banks of Brouillett's Creek, near the north line of the county. A pit has here been opened on the Guy Briggs place, on the southeast quarter of the northwest quarter of section 4 (13 N., 9 W.). It is in the bank of a little creek, and shows a face of 10 to 15 feet of gravel with 2 to 4 feet of soil and clay. The sand in the pit and in the creek bed appears to be nearly pure quartz. The coarser material is largely of granite and limestone pebbles, with many rotten stones, pieces of coal and shale, and an occasional lump of boulder clay. This deposit extends easterly into the northeast quarter of section 4, and is at least from 6 to 8 acres in extent and of unknown depth. There are also several acres of gravel on Fred Armstrong's place, on the northeast quarter of section 3 (13 N., 9 W.). On the uplands west of the river valley there is practically no bank gravel.

Area East of the Wabash River.

East of the river there is practically no workable gravel in the uplands, and only a few small deposits along some of the streams. Along the bluffs north of Otter, Honey and Prairie creeks there are immense deposits of fine sand and many sand hills that seem to be sand dunes, but they contain no gravel. The sand and

gravel in the big terrace in this part of the county is practically inexhaustible. Only a few good gravel pits have been opened, and those are in the vicinity of Terre Haute. Considerable quantities of good sand and gravel have been taken from the banks and bed of Spring Creek. There is a gravel pit on the northeast quarter of the northwest quarter of section 31 (13 N., 9 W.), and 2 near the railway on the east half of section 13 (13 N., 8 W.). Several other small pits occur in Otter Creek Township, but none of great importance.

In Harrison Township there are three large gravel pits in the south part of section 9, and an abandoned pit across the street on the northeast quarter of section 16 (12 N., 9 W.). There is an abandoned pit along the Big Four Railway in the southwest quarter of section 1, another on the northeast quarter of section 2, and one on the southwest quarter of section 3, in the banks of Lost Creek. The Vandalia Railway has a gravel pit on the southeast quarter of section 14. Other old pits occur on the south half of the northeast quarter of section 26, on the southeast quarter of the southeast quarter of section 27, on the northeast quarter of the northeast quarter of section 34, and on the northeast quarter of the southeast quarter of section 33 (12 N., 9 W.). There is also a pit along the terrace on the northwest quarter of section 33.

The Southern Indiana Railway has a pit along the edge of the terrace on the southeast quarter of section 32 (12 N., 9 W.), extending southerly into the northeast quarter of section 5 (11 N., 9 W.). There is also a large pit on the south half of the southeast quarter of section 35 (12 N., 9 W.), which has supplied gravel for several miles of road on the uplands to the south and east.

Farther south, in Prairieton Township, there is a great body of gravel in the southwest quarter of section 34 and the southeast quarter of section 33 (11 N., 10 W.), and on sections 3, 4 and 9 (10 N., 10 W.). On section 18 and the south part of section 7, same township and range, there is a great mound of gravel, about 100 acres in extent, rising more than 50 feet above low water in the river.

In the valley of Prairie Creek, on the southwest quarter of section 26 (10 N., 10 W.), is the Piety gravel pit, which has furnished material for gravel roads both in Vigo and Sullivan

counties. On the other side of the creek, on the northeast quarter of the northeast quarter of section 27, is the Trueblood gravel pit. There is also a small pit on the southeast quarter of section 29.

The gravel on the east side of the river is generally of excellent quality. The deposit on sections 9 and 16 (12 N., 9 W.) is quite coarse like that in the Railway pits at West Terre Haute. In the other pits the material is of finer grain with very few large pebbles.

CLAY COUNTY.

Area in square miles	357
Population in 1900	34,285
Miles of public roads	800
Miles of improved roads	218
Percentage of roads improved	27.2
Miles improved with gravel	186
Miles improved with crushed stone	32
Average original cost of gravel roads per mile	$2,000
Average original cost of stone roads per mile	$2,500
Total original cost of improved roads	$452,000
Annual cost of repairs per mile on gravel roads 5 years old	$100
Annual cost of repairs per mile on stone roads 5 years old	$100
Miles of improved roads (gravel) built in 1905	8
Miles of improved roads(stone) built in 1905	21
Miles of improved roads (gravel) contracted for 1906	25
First improved roads built	1892
Proportion of improved roads built since 1895 (per cent.)	75
Satisfaction of farmers with investment in improved roads	Good
Authority	Jacob Luther, County Commissioner

Clay County, in the western part of Indiana, is bounded on the north by Parke County, on the west by Vigo and Sullivan counties, on the south by Greene, and on the east by Owen and Putnam counties. It is 30 miles long from north to south and from 10 to 16 miles wide. The northern portion is drained by the branches of Otter Creek into the Wabash, and the southern portion by Eel River and its branches into White River. There is some broken country along the creeks in the northwest, also along Croy's Creek in the southeast, but in general the surface is quite uniform, the general elevation being between 550 and 675 feet above tide. While the surface is generally uniform, drillings for coal and mining operations show that the bed rock has been deeply

eroded and is furrowed by wide, deep channels with intervening ridges.

Prof. G. H. Ashley, in the Report of the State Geologist for 1898, page 520, says: "Some of these hidden channels have been revealed by mining operations or the drill. Thus, near Carbon, section 5 (13 N., 6 W.), three old channels exist, running southwest, one passing a short distance east of the Litchfield shaft, the other two, some 100 feet or so broad, crossing the property of Eureka No. 2 shaft, cutting out the upper coal. South of Carbon drillings are reported to have revealed a broad channel crossing section 7 (13 N., 6 W.), and running south on the top of the hill west of Otter Creek, then still south to the west of Brazil, then turning and passing south to Turner, section 11 (12 N., 7 W.), and going west into Vigo County. In like manner these old valleys have been met in all parts of the county." These preglacial channels often contain deposits of sand and gravel.

Clay County has about 220 miles of improved roads; about 160 miles improved with gravel, 20 miles with broken stone, and about 40 miles with broken stone as a foundation and gravel as a top dressing. The county is divided into 11 townships varying greatly in size.

Dick Johnson Township.

This township lies in the extreme northwest, being a part of township 13 north, range 6 west. The improved roads of this township in the main were built of gravel taken from the Leachman gravel pit on the southeast quarter of section 12 (13 N., 7 W.). This gravel seems to be in a preglacial channel, perhaps the one spoken of by Prof. Ashley as running southerly from Carbon. Mr. Leachman says: "My neighbors, east and west, have coal at the same level I have a bed of sand and gravel." Wells, drillings and mining shafts show the deposit to be at least 100 acres in extent, with a thickness of 10 to 50 feet. This deposit is opened along the bed of a little stream, where the gravel is covered with only from 3 to 5 feet of soil and clay, but outside this valley the soil and clay covering is from 15 to 30 feet thick. In general the water stands about at the surface of the sand and gravel.

Mr. Leachman has installed a pump throwing an eight-inch stream of water, sand and gravel. This material is screened into

two grades, a fine sand and a good gravel of rather small grain. The sand is composed mainly of quartz grains, while the gravel is largely of different kinds of granitic pebbles, with a large number of limestones. This material makes good roads and wears well. In this deposit I found no rotten or disintegrating pebbles, all being of good quality.

There are other deposits of sand and gravel in this township, but like the greater part of the Leachman deposit, the material is covered so deep with soil and clay that it can not be worked with profit. Some gravel is found in the beds of the streams, but it is seldom of good quality, and is not much used.

Van Buren Township.

Van Buren is the northeast township of the county, and includes the greater part of township 13 north, range 6 west. In this township are located the towns of Carbon, Cardonia, Harmony, Knightsville, Benwood and others. The improved roads in this township have been made for the most part of gravel found on sections 8, 10 and 11 (13 N., 6 W.).

The Lamb gravel pit, on the southeast quarter of section 11, about four miles north from Harmony, has supplied most of this gravel. There seems to be a large deposit of good road material in this locality, but I could get no definite idea as to its depth or area. The gravel is somewhat yellowish in color and contains some rotten pebbles, due to oxidation. It makes a fairly good road, but does not wear as long as some other gravels. The pit was not open for use in the season of 1905, and the investigation was therefore not very satisfactory.

The McQueen gravel pit, on the northeast of the southwest of section 10 (13 N., 6 W.), and the Bell gravel pit, on the southeast of the northwest of the same section, are in a deposit of what seems to be a good road material. It is at least 6 to 8 acres in extent and 8 to 15 feet thick. About 5 miles of road have been improved with gravel from these pits. The roads are fairly good and the material wears well. In general, this material is covered with from 3 to 5 feet of soil and clay.

The Charles Orme pit, on the northwest quarter of the northeast quarter of section 8 (13 N., 6 W.), is in a deposit several acres in

extent, and from 3 to 12 feet in thickness. The deposit is opened along the bed of a little stream, where it is covered with from 1 to 3 feet of soil and clay. The pit was opened in August, 1905. Water was reached about 1 foot below the surface of the gravel. A horse-power pump lowered the water about 4 feet, so that about 5 feet of gravel could be worked. The material is a clean gray or bluish gray gravel, becoming lighter when exposed to the sun on the road. As a whole it is rather fine, with more sand than gravel. The larger pebbles are granite and limestone, with occasionally one of quartz, while the sand is mainly of quartz grains. The material seems to be about like that in the Leachman pit, about 3 miles farther west. It packs well and promises much as a road material.

Brazil Township.

Brazil Township is 2½ miles square in the south part of township 13 north, and partly in range 6 and partly in range 7 west. There are no workable gravel deposits in this township. Its roads have been improved mainly with gravel shipped in from West Terre Haute, in Vigo County. Some material for street improvement in the city of Brazil, came from the Summit Grove gravel pits in Vermillion County.

Posey Township.

This corresponds to township 12 north, range 7 west. There is practically no workable gravel in this township and no rock available for road purposes. Some roads have been improved with gravel shipped from West Terre Haute, Vigo County.

Jackson Township.

This corresponds to township 12 north, range 6 west. There is practically no available road material in this township. Some roads in the western part of the township have been improved with gravel from West Terre Haute, while some in the eastern portion were built of gravel from the Trester pit in Putnam County.

Cass Township.

This township, consisting of 12 sections east of the southern portion of Jackson Township, has but little road material. Some

roads were improved with gravel from the Trester pit. Later, some new roads have been built and old ones repaired with gravel taken at various places from the bed of Eel River above Bowling Green.

Washington Township.

This township, south of Jackson and Cass, has some gravel in the beds of Eel River and its tributaries. Some roads were improved with gravel from the Trester pit, but gravel for repair work was taken from the bed of Eel River, while some roads have been improved with river gravel, which seems to be good road material.

Sugar Ridge Township.

This township, lying west of Washington, has no available road material. The sand bars in Eel River along its southern border do not contain good road material. Some roads in this township have been improved with gravel from West Terre Haute.

Perry Township.

This township, adjoining Vigo County in townships 10 and 11 north, has no available road material and practically no improved roads.

Lewis Township.

This is the southwest township of Clay County. There is practically no available gravel in this township. Some roads have been improved with gravel from West Terre Haute. Others have been improved with broken sand rock about 8 inches thick, covered with about 4 inches of gravel, from West Terre Haute. The stone was quarried on Mr. Barrett's farm, section 29 (9 N., 7 W.), and on the Harris land, section 20 (10 N., 7 W.).

Harrison Township.

This township, the southeast portion of Clay County, is 12 miles long from north to south, extending through townships 9 and 10 north. In this area considerable road has been improved with river gravel, which is said to make fairly good road material.

Some roads have been improved with rock and gravel, as follows: Broken sand rock about 6 inches, covered with river gravel about 6 inches. This combination is said to make good roads, but their durability is questionable. The rock for these roads is quarried on the Cooprider place about 2 miles southwest of Clay City.

SULLIVAN COUNTY.

Area in square miles	440
Population in 1900	26,005
Miles of public roads	974
Miles of improved roads	332
Percentage of roads improved	34.1
Miles improved with gravel	272
Miles improved with crushed stone	60
Average original cost of gravel roads per mile	$2,600
Average original cost of stone roads per mile	$3,200
Total original cost of improved roads	$844,623
Annual cost of repairs per mile on gravel roads 5 years old	$50
Miles of improved roads (gravel) built in 1905	22
Miles of improved roads (stone) built in 1905	30
First improved roads built	1895
Satisfaction of farmers with investment in improved roads—	"As a rule good"
Authority	E. E. Russell, County Auditor

Sullivan County borders on the Wabash River and is bounded on the north by Vigo County, on the west by Illinois, on the south by Knox County, and on the east by Greene and Clay counties. It is 24 miles in length from north to south and has an average width of about 18 miles. The greater part of the county is drained into the Wabash through Thurman's and Busseron creeks. The southeastern portion of the county drains into White River. The surface is generally level. Some broken country lies along the streams, but the bluffs are not more than from 25 to 75 feet high, and the valleys are wide. About one-fifth of the area is flood plain and terrace.

The Wabash flows along the bluff at Narrows, on section 25 (9 N., 11 W.), and again at Merom, on sections 7 and 18 (8 N., 10 W.), thus cutting the flood plain and terrace into three portions Above Merom they are from one to three miles wide and the terrace is quite sandy. Below Merom they are from 2 to 4 miles wide and the terrace is made up more largely of gravel. There

is sandstone at the Narrows, and at Merom the sandstone bluff is about 170 feet high. Good sandstone outcrops at several places in the county.

Sullivan County has about 250 miles of improved roads and about 80 miles in process of construction. Of the new roads, about 50 miles are being made of stone, the balance of gravel. Some of the stone comes from Thornton, near Chicago, some from Spencer, some from Bedford and some from local quarries. The gravel is, in general, from local pits.

Fairbanks Township.

Fairbanks, the northwestern township of the county, consists of flood plain, terrace and upland. There is an abundance of sand in the terrace, the gravel occurring in isolated localities. The pits furnishing gravel for improving roads in this township are Hunt's pit, on section 6; Bowen's pit, on section 7; Bostick's pit, on the north half of section 19, all in township 9 north, 10 west, and Parker's pit, near the Bostick pit. In addition, some gravel is obtained from the Piety and Trueblood pits, in Vigo County. In general, this gravel is of good quality, but rather fine for first-class road material.

Thurman Township.

This township borders on the river south of Fairbanks. The surface is much as in Fairbanks Township. The pits furnishing gravel for this township are Nowlin's pit, on the northwest quarter of section 23; Gray's pit, on the northeast quarter of section 23, and Monk's pit, on the southeast quarter of the northwest quarter of 14 (8 N., 11 W.). This gravel is said to be very good road material.

Gill Township.

Gill Township borders on the river, but the flood plain is not as wide as in Thurman Township. Below Merom the terrace for some distance is near the river. Roads have been built with gravel from Woods' pit and from the Niles pit, both near Merom Station, on the southeast of the southeast of section 20 (7 N., 10 W.). The Merom Gravel Company's pit, on the south half of section 20, has furnished large quantities of gravel for local use,

and from it large quantities have been shipped. The pits about Merom Station have from 20 to 30 feet of gravel down to water, with very little soil and clay. The deposit extends to the river and the gravel company is pumping gravel from the bed of the river. Considerable gravel has been taken from two pits on the Funk land, on section 10 (6 N., 10 W.). Sand and gravel are abundant in Gill Township, but good road material occurs at irregular intervals.

Haddon Township.

This township is somewhat irregular in form, having only about two and a half miles of river front. The gravel and sand terrace extends from Gill Township across Haddon into Knox County, but the Wolf pit, on section 25 (6 N., 10 W.), is the only one of importance that has been opened in the township. The roads have been made mainly from the Funk pits and the Wolf pit, and of gravel from Emison, in Knox County.

Hamilton Township.

Sullivan, the county seat, is located in this township. There are about 17 miles of gravel and seven miles of stone roads within its bounds. The gravel came from the pits in Gill Township, and from Emison, in Knox County. The stone came from Spencer, Owen County, and from Thornton, near Chicago. There is no gravel and no stone in the township available for roads.

Curry Township.

There is practically no good road material in this township. The roads have been improved mainly with gravel from the Piety pit in Vigo County, while some came from Emison, in Knox County.

Jackson, Cass and Jefferson townships, comprising the eastern portion of Sullivan County, have no available gravel. The gravel used came from Merom Station, in Gill Township, or from Emison. Some stone road has been made of material from Spencer or Thornton. Some native rock has been used, but in general it is not of very good quality.

KNOX COUNTY.

Area in square miles	510
Population in 1900	32,746
Miles of public roads	580
Miles of improved roads	264
Percentage of roads improved	45.5
Miles improved with gravel	200
Miles improved with crushed stone	64
Average original cost of gravel roads per mile	$1,800
Average original cost of stone roads per mile	$2,000
Total original cost of improved roads	$488,000
Miles of improved roads (gravel) built in 1905	35
Miles of improved roads (stone) built in 1905	5
Miles of improved road (gravel) contracted for 1906	40
First improved roads built	1900

Satisfaction of farmers with investment in improved roads—

"Many are of the opinion that better roads should be built for the money, as the cost for repairs is already large, though none of the roads have been built five years."

Authority...T. H. Adams

Knox County lies south of Sullivan, and is bounded on the west by the Wabash River, and on the south and east by White River. It is very irregular in outline, having an area of about 510 square miles. The surface is generally level or gently undulating, with some broken country in the northeast. Lying between the two rivers, the slopes are short and gentle, so that no large streams occur. Along the rivers the flood plain is from one to three miles wide. Along the Wabash there is considerable gravel terrace, but there is very little gravel in the valley of White River.

A large portion of Knox County was settled before the adoption of the rectangular system of survey, so that a portion of the county is divided into sections, while other portions are divided into surveys and donations, the dividing lines, in most cases, running northeast-southwest and northwest-southeast, though in some cases they are irregular.

Busseron Township.

This township is in the northwest part of the county. There is a great body of sand and gravel in its area, the sand largely predominating. Gravel occurs in workable quantities on sections

and from it large quantities have been shipped. The pits about Merom Station have from 20 to 30 feet of gravel down to water, with very little soil and clay. The deposit extends to the river and the gravel company is pumping gravel from the bed of the river. Considerable gravel has been taken from two pits on the Funk land, on section 10 (6 N., 10 W.). Sand and gravel are abundant in Gill Township, but good road material occurs at irregular intervals.

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Busseron Township.

This township is in the northwest part of the county. There is a great body of sand and gravel in its area, the sand largely predominating. Gravel occurs in workable quantities on sections

11, 12, 13, 14, 23, 24, 25, 26, 35 and 36 (4 N., 10 W.), and on donation 210 between sections 13 and 24; also on sections 2, 11 and 13, and on donations 204, 205, 209, 211, and on other land along the ditch and railway in township 3 north, range 10 west.

On donation 204 the Terre Haute & Evansville Railway Company have a large gravel pit. The A. Pfafflin Gravel Company are working the pit. They pump the material and screen it to suit the purchaser. They can furnish from 300 to 350 cubic yards of screened gravel per day. As ordinarily screened, about half the deposit is sand, which is of excellent quality, being nearly pure quartz. The screened material consists mainly of granite and limestone pebbles, and has a good reputation as a road material.

Several pits of small size have been opened on the tracts of land mentioned above, for local purposes, but none are of much importance. The railway pit is about two miles southerly from Emison, and the gravel is generally known as Emison gravel. Dr. Orman's pit, Purcell's pit and the Grand Crossing pit are located two to three miles west and north of Emison.

Washington Township.

This township has a frontage of about two and a half miles on the river and extends easterly about eight miles. There is some flood plain along the river and a little terrace material, but in general the surface is clay. There is practically no gravel nor stone in the township available for road making. The improved roads within its bounds are made of gravel from the railway pit, near Emison.

Vincennes Township.

This township is about 14 miles long from north to south, including all of townships 2 and 3 north, with about two miles of township 1. It has a river frontage of at least 25 miles. In the north the rock bluff at old Fort Knox is washed by the river, and for a mile or so there is no flood plain nor terrace.

Three and a half miles south of the "Old Fort" is the city of Vincennes. It stands on a terrace of sand and gravel that, in the north, rises from 30 to 40 feet above low water, diminishing in elevation toward the south. Gravel is abundant. Lanahan &

O'Donnel have a large pit in the edge of the terrace on the west, where there is 20 to 25 feet of gravel down to ground water. This company has another pit in the north part of the city, near the edge of the terrace, and the city of Vincennes has a gravel pit in the same neighborhood. O'Donnel has two pits near the railway south of the city. One of these Mr. O'Donnel calls a sand pit, the sand making up four parts and the gravel one part. The other, which he calls a gravel pit, is composed of four parts gravel and sand one part. The material is much alike in these pits. The sand is nearly pure quartz and good for plastering or concrete work, while the coarser material makes good roads. The O'Donnel gravel pit shows from 6 to 8 feet of gravel to water, and he has pumped the material to a depth of 17 feet below water level. At least ten miles of road have been built from this pit, besides large quantities of gravel that have been used for improving the streets of the city. There is a gravel pit near the coal mine in the eastern part of the city, and others in the south in the neighborhood of O'Donnel's pit.

South of Vincennes, along the terrace, there are several small gravel pits. These are the Brevoort pit, the Whitehead pit, owned by the township, and the Vieke pit, about five miles south of the city. The county also has a pit on the Dicksbury road, about two miles south of the city. The township is well supplied with gravel, but there is not much improved road south of the city.

Decker Township.

This township is in the southwestern part of the county. It has the Wabash on the west and White River on the south and east. There is considerable sand and gravel in the township, but no pits of importance have been opened. Practically no roads in this township have been improved with either gravel or stone.

Johnson Township.

This township lies south and east of Vincennes Township. In general it has quite a uniform surface. There is plenty of sand and clay, but no gravel or stone that is available for road building. The roads in contemplation are to be built of imported gravel.

Harrison Township.

This township is in the southeastern portion of the county. It has no bank gravel and no available stone for road building. There is some gravel in sand bars along the river, but it is not called good road material. There are practically no improved roads in this township.

Palmyra Township.

This township lies east of the northern part of Vincennes Township. It has no gravel and no stone available for road building. The improved roads in its area have been made of gravel from Emison or from Illinois, brought in by the B. & O. S. W. Railway.

Steen Township.

This township, lying east of Palmyra, has no good road material except what may be found in sand bars along White River. Some roads have been improved with gravel from Emison or from Illinois.

Vigo Township.

This township extends from Steen northeasterly along the river to the north line of the county. It has about 35 miles of road improved with stone, mainly from Spencer, Owen County, quarries. About three miles of road were improved with stone from local quarries. The quality of the latter appears to be good, but the beds are thin and the stripping heavy, so that it probably can not be worked at a profit. There is no gravel except a little in the river sand bars.

Weidner Township.

This township lies along the north line of the county, between Busseron and Vigo townships. There is practically no gravel within its area. It has 22 miles of road improved with broken stone. About ten miles were improved with stone from local quarries, and the balance with imported stone.

The most extensive local quarry is on section 21 (4 N., 8 W.), owned by Gustave Stoelting, a section of which shows—

Section of Quarry on Stoelting Farm.

		Feet.
1.	Soil and clay	3 to 6
2.	Shale rock	2
3.	Hard limestone	4

The limestone makes good road material, but, as worked, it costs more than imported stone. There are several outcrops of this rock in the township, but in no case does it occur in such form as to promise that it might be quarried with profit.

SECTION X.

THE ROADS AND ROAD MATERIALS OF A PORTION OF CENTRAL INDIANA.

EMBRACING THE COUNTIES OF PUTNAM, HENDRICKS, MARION, MORGAN, JOHNSON AND SHELBY.

BY E. J. CABLE.

The territory covered in this report includes a strip of country in the central part of Indiana, extending from near the eastern to near the western border of the State.

NEED OF ROAD IMPROVEMENT.

A careful examination of the roads in the various counties worked reveals the fact that there are many miles of unimproved roads, as well as many that have been improved that need remodeling. Some counties, though well supplied with good road materials, have not made the advancement in improvement made by others not so well supplied with the necessary materials. This is probably due to the lack of the right kind of feeling with regard to the matter, or to the indifference of the farmers, to whom the question of good roads should appeal with great force. Many farmers do not stop to think or reason that the value of their property is raised or lowered in accordance with the conditions of the roads of the community. The American people of today, and especially the farmer, is quite particular as to the house he lives in, the manner of vehicle he uses, the style and breed of horses he drives, but is quite indifferent of the animals' feelings when he forces them to draw a load of produce to market, over roads so deep with mud that the animal sinks in to the knees at every step. A country with good roads is always a prosperous one and one that holds high rank among the nations of the world. The counties leading in road improvement are Marion, Putnam and Johnson.

The writer was strongly impressed with the fact that in counties where road improvement has been made and is being made, it has enhanced the value of land to the extent of ten and fifteen dollars an acre. When good roads have become universal through the country, the land that is now farthest from the market will bring a much higher price than the same land will now bring with the roads unimproved. Availability of markets will then not be a serious problem.

Materials Used for Road Improvement.

The materials used for road improvement in these areas are gravel and limestone. Gravel is the one most extensively used, as limestone is not available in all the counties, and if used must be shipped in from counties that have it. This is being done in several of the counties worked, where gravel is a scarce article.

Gravel.

The gravel of the region covered occurs in various topographical positions. In some of the counties it occurs in kames and eskers, associated with the terminal moraine or with the recessional moraine, while in others it occurs in flood plains of streams, in bluffs along the river or smaller streams, while in still others it is found in local pockets of the ground moraine, in pockets in old valleys and as valley trains and flood plain terraces.

The gravel deposited by fluvial action may easily be determined by its peculiar stratification. The fluvial deposits make up by far the larger per cent. of gravel deposits of economic importance.

Next to those of fluvial deposit are those of glacial deposition. These deposits are likewise easily determined by their peculiar stratification and character of material. In many cases the origin of a large percentage of these deposits is the weathering of the country rock by oxidation, chemical reactions, temperature changes and stream erosion, together with glacial erosion.

There are some lacustrine deposits found in the western part of Morgan County, but they are of little value for road purposes, as the gravel is too sandy. These deposits make up but a very small part of the gravel of economic importance.

Quality of Gravel.—The quality of the gravel is determined by the composition, the oxidation that it has undergone, the size of the pebbles and the cementing principle. Often large deposits are of little value, because of poor cementing qualities, or because the pebbles are too small, or of too soft a material. In other places, especially in counties where the Mitchell limestone outcrops, many of the deposits are of little value because of the large percentage of such limestone.

Availability of Gravel.—The workable deposits are not in all cases so located as to be of the greatest advantage. In many cases the deposits are small in amount of good gravel. Such is the case where we have small pockets in the ground moraine or pockets in the river valley. In other cases we have fairly good deposits in areas where gravel is scarce, but the gravel is covered so deeply that it is very difficult to get at. In this case the expense of getting the gravel out of the pit is great. It often happens that gravel occurring along the river in the old flood plain, or a valley train, can not be quarried because of interference of ground water. In such cases the gravel must be dipped or pumped. This means that the expense per yard is trebled. In many cases the problem of transportation enters into the question of availability. Often the deposit is of little value because of the distance the material must be hauled, or is so located as to be almost impossible to get to.

LIMESTONE.

The problem of suitable limestone is not an easy one, as limestone does not outcrop in all the counties. Limestone of workable quality outcrops in Putnam, Morgan and Shelby counties.

Morgan County is especially rich in good limestone in the southwestern part, in Ray Township. The central and southern parts of Putnam County have unlimited amounts of good stone. In this county several crushers are at work supplying stone to the county and to other distant points in the State and outside the State.

Some stone outcrops in Shelby County along the Big Flatrock River. In every case the limestone outcrops along the stream's bluff or is found in the stream's bed.

Since some counties are well supplied with gravel and others well supplied with stone, the cost of road improvement will largely

depend upon the material used. The average cost of road improvement with stone is $2,000 per mile, while the average cost for gravel is but $1,000 per mile.

The average wearing quality of the two materials was carefully noted, and it was found that a road properly graveled would wear at least five years without further improvement, while those of stone required some repair work within the same time. This was probably due to the fact that the road was not properly built in the first place, or else poor stone had been used.

The gravel deposits of the counties worked will now be described. Each county is worked out very carefully with regard to both limestone and gravel deposits, sections of the pits and quarries having been taken. With each county is a map of the same showing the distribution of the quarries and the location of the gravel deposits.

PUTNAM COUNTY.

Area in square miles	482
Population in 1900	21,478
Miles of public roads	900
Miles of improved roads	635
Percentage of roads improved	70.5
Miles improved with gravel	335
Miles improved with crushed stone	300
Average original cost of gravel roads per mile	$1,500
Average original cost of stone roads per mile	$2,000
Total original cost of improved roads	$1,102,500
Annual cost of repairs per mile on gravel roads 5 years old	$50
Annual cost of repairs per mile on stone roads 5 years old	$40
Miles of improved road (gravel) built in 1905	20
Miles of improved roads (stone) built in 1905	36
Miles of improved roads (gravel) contracted for 1906	12
Miles of improved roads (stone) contracted for 1906	6
First improved roads built	1868
Proportion of improved roads built since 1895 (per cent.)	65

Satisfaction of farmers with investment in improved roads—

"They are highly pleased, are wanting more improved roads and are disappointed because the law allows only 4 per cent. the assessed value of the township to be used for road improvement."

Authority............................J. F. O'Brien, Ex-County Surveyor

The northern part of Putnam County is comparatively level, while the southern is extremely rough. In the southern part, especially in Cloverdale Township, the drift capping the hills of

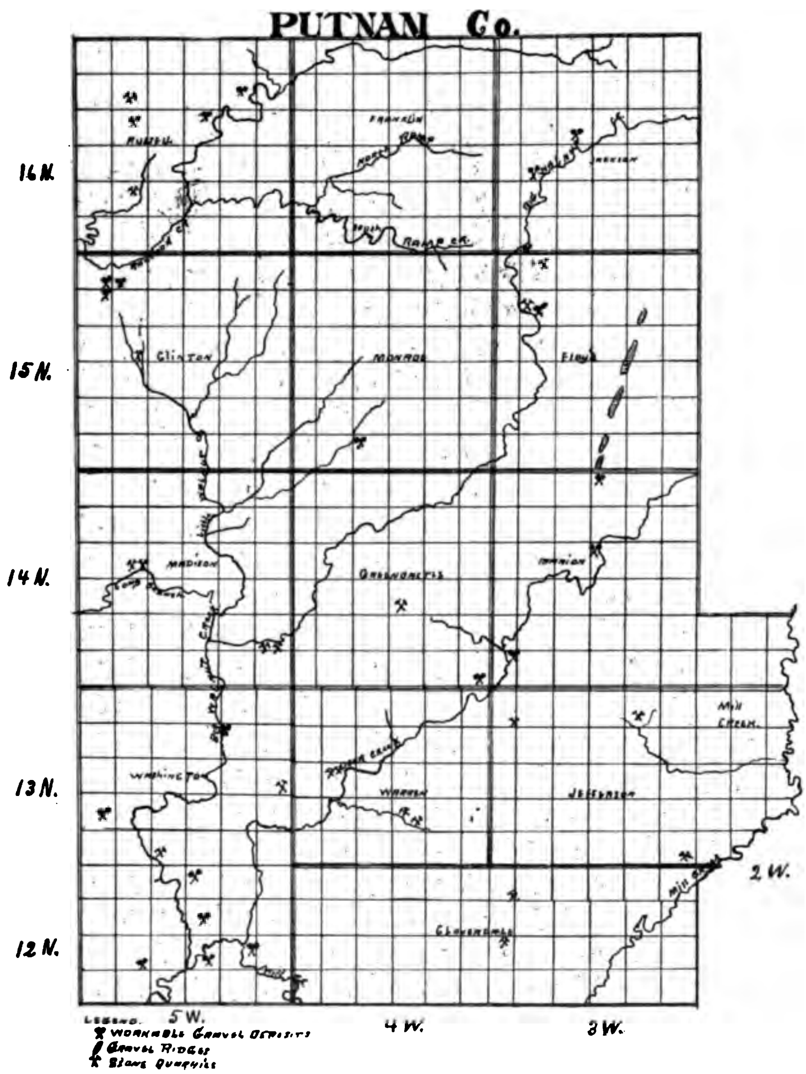

Fig. 43. Illustrating the distribution of road materials in Putnam County.

Mitchell limestone, is extremely thin, and is the older of the two found in the county. In the northern part of the county the drift is much thicker, and limestone outcrops along the small streams are not so numerous. Two ages of drift are readily discernible in Putnam County. In the north, the latest extends as far south as Greencastle, the county seat, then strikes off in a southeasterly direction.

Road improvement in Putnam County is not a difficult one. There is plenty of material, both stone and gravel, and within easy reach of unimproved roads. At present there is a strong sentiment in the county in favor of good roads, and this sentiment should result in improvement in every part of the county.

Most of the important roads of Russell, Franklin, Jackson, Monroe, Floyd, Marion, Washington, Jefferson and Greencastle have been graveled or rocked. The improvement has not been so rapid in the south central and eastern parts, owing to the fact that gravel is not plentiful, and what improvement is made must be made with crushed rock. The materials available in Putnam County are gravel and limestone.

Gravel Deposits of Putnam County.

Gravel deposits are plentiful in the following townships: Washington, Marion, Floyd, Jackson and northwest Clinton townships. Bar gravel is found in Clinton, Greencastle and Madison.

Clinton Township.

Julia A. Ratcliff Pit.—Northeast quarter section 7 (16 N., 5 W.). This pit is located in the bluffs bordering Raccoon Creek. The known depth of gravel is 25 feet, and the circumference 900 feet.

Section of Ratcliff Pit.

		Feet.	Inches.
1.	Clay stripping	4 to 6	......
2.	Gravel and clay	......	6 to 8
3.	Gravel mixed with fine layers of sand	8 to 10	......
4.	Seam of clay	1 to 2	......
5.	Clean gravel	6 to 8	......
6.	Hard blue till	......	......

The best gravel runs in lenses or pockets. It may thus be ob-

tained free from clay or dirt. In size the pebbles average from one-half to one-fourth of an inch in diameter. A great many large granite boulders, as well as pillars and masses of clay, are found throughout the deposit, but not in such quantities as to be harmful. The gravel is interbedded with thin seams of sand, averaging from one-half to six inches in thickness.

The gravel is well stratified, and of a grayish blue color. Quartz, diabase, hornblendite, schists and basalt pebbles predominate, while limestones are in abundance.

The deposit is off the main road about one-quarter of a mile, but is easily gotten to, so that the transportation is not a difficult problem.

Unlike so many other pits, this pit is free from water, so that all the gravel may be taken out without extra expense. The stripping is the most difficult part, as there is from 6 to 8 feet of clay that must be removed before the gravel can be gotten at. Care should be exercised, so that little of the dirt gets into the gravel. The price for both township and county purposes is 7 to 10 cents per yard, the owner stripping the pit and keeping it in good condition.

Something like five miles of road have been graveled from this pit. At present the gravel hauled has been used for repair work only. Roads examined where this gravel has been on for several years shows the gravel to be of good wearing quality. It packs well where the gravel has been taken from the pit free of dirt, making a smooth, even roadbed.

Walter H. Sigler Deposit.—Southeast quarter of the southeast quarter of section 6 (15 N., 5 W.). This deposit is located in the bluffs along Raccoon Creek. The hills are elliptical in shape, in every case being covered with from 2 feet to 4 feet of clay.

By means of spade and post auger I was able to make the following estimate as to size of deposit:

Depth of deposit	20 feet
Circumference of hill	625 feet
Diameter	200 feet

The gravel is of a grayish blue color, except the upper 8 or 10 inches, which is highly oxidized. The pebbles average from one-fourth to one-half inch in size. Lenses of coarse, bluish gray sand are found throughout the deposit.

This deposit has not been opened up, but can be with very little cost, as it will be an easy matter to dump the stripping in the gullies below and make a roadway out to the main traveled road, which is about one-fourth of a mile away.

Russell Township.

Bert Long Pit.—Northeast quarter of the northeast quarter of section 15 (16 N., 5 W.). This pit is situated in the bluff bordering Raccoon Creek, and is river-deposited gravel. The deposit has been a large one, but has been extensively used, so that there is not more than 10,000 cubic yards left.

Section of Pit on Land of Bert Long.

		Feet.	Inches.
1.	Clay stripping	6 to 8	......
2.	Clay mixed with gravel—oxidized	......	6 to 8
3.	Sand and gravel—sand interbedded	6 to 8	......
4.	Clay	2	......
5.	Gravel with lenses of sand	14 to 16	......
6.	Hard bluish clay.		

There is a great amount of sand and dirt in this deposit of gravel, which can not be avoided because of the difficulty in stripping. The best gravel occurs in pockets, which are surrounded by sand. Sand is continuous throughout the deposit, the layers of gravel being interbedded between thin layers of sand. In different parts of the deposit lenses of clay are prominent. The pebbles are largely quartz, with limestone in abundance. In portions of the pit the whole mass is cemented together by lime, thus forming a conglomerate.

This deposit is difficult to get at, being about one to one and one-half miles off the main road. A deep ravine must be crossed, and several steep hills must be pulled up. The price charged both county and township is 10 cents per yard.

Brumfield Deposit.—Southeast quarter of section 11 (16 N., 5 W.). This deposit is located in the bluffs bordering a ravine of Raccoon Creek. The pit has been worked to some extent and is in a long ridge bordering a flat.

Section of Brumfield Deposit.

		Feet.	Inches.
1.	Clay	1 to 2	..
2.	Oxidized gravel and clay	....	6
3.	Gravel with intersected layer of sand	10	..

It is impossible to get to the bottom of the gravel on account of ground water. Just west of the barn is a deposit of some value, which has not yet been opened.

This gravel is not of the best quality. There is a large amount of dirt in it, and a large part of the pit shows fine gravel. There is little clay present. Only the upper part shows oxidation, while the larger part is of a grayish blue color. The pebbles average from one-fourth to one-half inch in size. The deposit is rather unfortunately located, as it is off the road some distance, and to get to it a rather hilly road must be traveled. Little stripping is required, as the gravel comes very near to the surface. But very little can be said with regard to its wearing qualities, as it has been used but little on the public highways.

Frank McGaughey Pit.—Section 26 (16 N., 5 W.). This pit is of fluvial origin and is situated in the bluff bordering Raccoon Creek. It is one of the largest and best deposits in Russell Township, the estimated amount present being 20,000 cubic yards.

As the deposit is located right on the main traveled road, it is very easy to get to it, and thus the pit is more valuable. Not only is the deposit well located, but it is so near the surface that little stripping is required. The bluff bordering the old flood plain of Raccoon Creek is about 60 feet high, so that no interference is experienced with ground water.

Section of McGaughey Pit.

	Feet.	Inches.
1. Clay and soil	1 to 1½	..
2. Clayey gravel	....	6
3. Gravel interbedded with thin layers of sand	30	..

Since little stripping is required and the gravel itself is free from dirt, it is of excellent quality. The average size of the pebbles is one-half inch. There are pockets where much coarser gravel may be had. The color is a light grayish blue. About 75 per cent. of the pebbles are quartz, with some limestone and other rocks. There is enough limestone to form a good cement. The owner strips the pit, and receives 15 cents per cubic yard for all gravel hauled out.

Since this pit has been opened for a short time, but few miles have been graveled, but roads examined where this gravel has been

used show it to be a material that packs well and suffers little abrasion by traffic.

Molly Crodian Pit.—Southwest quarter of section 23 (16 N., 5 W.). This deposit is a long, narrow tongue-like hill, about one-fourth of a mile in length, 50 to 75 feet wide, and 20 to 25 feet high. By prospecting along this ridge, gravel was found running its entire length.

Section of Crodian Pit.

	Feet.	Inches.
1. Blackish soil	......	6 to 8
2. Yellowish clay	......	12 to 18
3. Gravelly clay	......	6
4. Gravel interbedded with layers of sand	10 to 12	....
5. Boulder clay.		

This gravel is not of a good quality, because there is too much sand and clay mixed with it. There is about 40 per cent. of dirt and sand present. The gravel is of a dark, grayish color, very small, averaging one-fourth inch in diameter. Little of this material is being placed on the road, as the McGaughey pit is close by.

J. W. Sutherlin Deposit.—Northeast quarter of section 26 (16 N., 5 W.). This deposit outcrops on the side of a steep bluff bordering the old, wide flood plain of Raccoon Creek, and is of fluvial origin.

The height of the hill is about 60 feet. By boring down into the side of the hill it was found that the gravel extended back into the hill 200 or 300 feet, with a vertical depth of 30 feet to bottom of cliff. A well dug some distance away from the bluff, on the flat, showed gravel below the water table. The deposit is a large one and of excellent quality.

The deposit is right on the main traveled road and but a short distance from unimproved roads, and is therefore easily gotten at. As the gravel outcrops at the bottom of the hill, little stripping is necessary. The deposit can easily be opened when necessary.

The gravel is of a grayish color, is free from clay and dirt, and is of good size. Numerous boulders are present throughout the deposit, the predominating type being those of granite. The gravel is largely made up of quartz, with quite a percentage of good-sized, flat limestone pebbles.

Franklin Township.

This township has no pit gravel. The southwestern part is supplied with gravel from the beds of South and North Ramp creeks. Gravel is also hauled from Jackson and Russell townships.

All of the important roads of the township have been graveled.

Jackson Township.

Charles Johnson Pit.—Southeast quarter of section 20 (16 N., 3 W.). This deposit is located in a high tongue-like hill bordering Walnut Creek. It is probably of fluvial origin.

Length of hill	300 feet
Width of hill	50 feet
Depth of hill	30 feet

Section of Old Pit, South Side.

		Feet.	Inches.
1.	Clay	2 to 4	....
2.	Fine gravel, mostly sand	1 to 1½	....
3.	Coarse gravel with thin layer of sand	2 to 4	....
4.	Boulder clay, occurring in lenses	1 to 1½	....
5.	Coarse gravel	5 to 6	....
6.	Gravel interbedded with fine layers of sand	....	8 to 12
7.	Gravel for unknown depths.		

Section, North Side.

		Feet.
1.	Clay	3 to 6
2.	Fine sand	1 to 1½
3.	Gravel with very thin layers of sand	10 to 15
4.	Boulder clay.	

The gravel is of a bluish gray color, is free from dirt and clay, as the clay occurs in pillars or lenses and can easily be separated. The gravel is well stratified, dipping from the north to the south, side, in the southeast direction. The size varies in different parts of the pit. In some parts coarse material may be had, while in others finer may be obtained.

This deposit is located right on a main traveled road. Not all of the best gravel can be gotten, as water interferes after a certain depth has been reached. A rod was run down in the water

and it was found that excellent gravel is below the ground-water level.

This pit has been opened nine years, and from 5 to 8 miles have been graveled from the pit, some gravel having been hauled into Franklin Township, Montgomery County. One road examined, where the gravel had been on for eight years, showed the road to still be in good condition. Little repairing was needed. The gravel packs well and wears little, making a hard, smooth roadbed. The pit is stripped and kept open by the owner, so that both the township and county pay 15 cents per yard.

A new deposit not yet opened was located a short distance north of the old one. This can easily be opened up, as little stripping is necessary, the gravel outcropping at surface of the hill.

Height of hill	30 feet
Width of hill	50 feet
Length of hill	150 feet

William Allen Pit.—Southwest quarter of section 16 (16 N., 3 W.). This deposit is located in the banks of a small stream tributary to the Big Walnut Creek and is of fluvial origin. There are three openings, with an estimated content of 10,000 cubic yards.

This deposit is off the road about three-quarters of a mile, and is rather difficult to get at, as it necessitates a pull over several steep hills.

Section of Allen Pit.

	Feet.
1. Clay stripping	1 to 4
2. Fine sand	1 to 1½
3. Stratified gravel and sand	10 to 12
4. Boulder clay.	

The gravel is of a grayish color, and free from dirt. Clay occurs throughout the deposit in the forms of lenses or pillars. As a whole the gravel is rather fine, and contains a great deal of sand. There is too much sand to make the gravel the best for road purposes. The pit is stripped and kept open by the owner, who charges both county and township 15 cents per yard for the gravel.

Floyd Township.

Big Four Railway Pit.—Northwest quarter section 34 (15 N., 3 W.). This deposit is but a part of a long ridge that extends in a northeast-southwest direction through sections 34, 27, 23, 14 and 11 in the east central part of Floyd Township. This ridge is not continuous throughout all these sections, but is in places disconnected. It is of glacial origin. The ridge in sections 11 and 14 is very prominent, reaching a height of from 75 to 100 feet. It is in one place more than 150 feet wide, and in many places the gravel outcrops at the top.

It is difficult to make an estimate of the amount of gravel, as all the hill is underlain with it. This pit was opened by the Big Four Railroad years ago. A large portion of the road built between Indianapolis and Terre Haute in 1870 was graveled from this pit.

Section of Big Four Pit.

	Feet.	Inches.
1. Clay	2 to 6	......
2. Clayey gravel oxidized	......	6 to 8
3. Cross bedded gravel and sand	20 to 30	......

The gravel is quite free from dirt and clay, is of a bluish gray color, and in sections of the pit rather coarse. Almost any degree of fineness may be had. On the north side of the pit toward the west end, the gravel is cemented together by lime, so that a morainic conglomerate is formed. To the extreme west end of the deposit may be found very fine sand, of a very light gray color, free from dirt or clay. There are few large stones present. The gravel is largely quartz, although considerable limestone is present. It is now sold for road purposes, the railway no longer using the pit.

The Loyd Campbell Deposit is located in the same section as the above. This deposit is just opposite the Big Four pit but has not been opened. It is in the form of a long ridge-like hill—probably a kame.

Length of hill	2,000 feet
Width of hill	150 feet
Height	50 feet

The gravel is of excellent quality, of a light gray color, and is free from dirt and clay. The average size of the pebbles is one-half inch.

Andrew Lewis Deposit.—Section 34 (15 N., 3 W.). This deposit is a part of the same ridge just mentioned. The owner has not yet opened the pit as there are a number of pits close by.

Robert Underwood Pit.—Northeast quarter of southwest quarter of section 23 (15 N., 3 W.). This deposit is of glacial origin, being a long, high, narrow tongue-like ridge.

Length of ridge........................	1,500 feet
Width of ridge.........................	100 feet
Height	60 feet

This pit is off the road some distance but is easily gotten to. The pit has been opened right on top of the ridge so that no stripping is necessary, as the gravel outcrops at the surface.

This is probably one of the best pits in this part of the township. The gravel is of a light gray color, free from dirt and rather coarse. It averages about one-half inch in diameter, and is largely quartz. Roads examined where this gravel has been on for two years prove it to be of good quality, in that it packs well and wears through slowly. The gravel is sold to both county and township for 10 cents yer yard. This pit has been opened for several years.

F. M. Chatham's Pit.—Northeast quarter of southwest quarter section 14 (15 N., 3 W.). In topographic position this deposit is the same as the former. It is but a continuation of the same ridge, known in this vicinity as "gravel ridge." The supply is sufficient to gravel many miles of road.

Length of ridge........................	600 feet
Width	100 feet
Depth	20 feet

Section of Chatham Pit.

		Feet.
1.	Clay	1 to 4
2.	Gravel with pockets of clay................................	1 to 1½
3.	Gravel with thin layers of sand and lenses of clay...........	12 to 14
4.	Boulder clay.	

This pit is located right on the road and is close to unimproved roads. The gravel is of a grayish blue color and is quite free from dirt and clay. Throughout the deposit occur immense granite bowlders. The gravel is coated with a thin film of clay so that when placed on the road it packs and makes a smooth bed. When placed on the road with little sand it makes an excellent road bed.

The owner being interested in good roads has stripped the pit, keeping it in good order, and charges 7 cents per yard and even as low as 5 cents per yard. A large amount of gravel has been hauled from this pit into Hendricks County.

Jacob Michaels Pit.—Central part of section 8 (15 N., 3 W.). This deposit is in the steep bluff along Big Walnut Creek. It is of fluvial origin and well stratified. It occurs up about 80 feet from the present river level.

The following measurements were made after careful prospecting:

Length	450 feet
Width	50 feet
Depth	15 feet

Section of Jacob Michaels Pit.

	Feet.
1. Clay	1 to 1½
2. Oxidized gravel and clay	1
3. Gravel interbedded with thin seams of sand	12
4. Boulder clay.	

This deposit is located right on the road just before crossing the bridge across Big Walnut. It is within one mile of unimproved roads, is easily gotten at and should be of value. The gravel is of good quality and makes excellent roads. The pit has been opened for four years and about 500 yards have been hauled out yearly. The owner strips the gravel and sells it to the township at 10 cents per load.

John S. Michaels Pit.—A deposit of six or more acres is located about a quarter of a mile west of the pit last described, on the land of John S. Michaels, Mrs. Sarah Rice and the Powers heirs. The pit as opened shows the gravel to be 16 feet thick above ground water, with a necessary stripping of about two and a half feet. The gravel is of excellent quality. It does not cave, but stands

perpendicular in the bank when the pit is opened, and can not be dislodged except by the use of the pick. It packs quickly and firmly when placed on the roads and has been used for 15 or more years.

The "Fish-line" road to the southwest was partly built of it, and it has been used for repairing roads five miles southwest, one and one-half miles east and two miles north. About one per cent. of the deposit is composed of large boulders, which have to be thrown aside.

Kaleb Richardson.—Southwest quarter section 9 (15 N., 3 W.). Here is a good sized deposit which has not been opened up. The gravel is of good quality, and could be used on the new road about one-half mile to the west, which is not graveled.

Marion Township.

The northern part of Marion is well supplied with gravel, but little could be located in the southern part. Some gravel is obtained from the bed of Deer Creek and its branches. In the northern part of the township the morainic ridge so prominent in Floyd township and so rich in gravel, begins to fade out, and almost fades out in section 20. More or less gravel is found in parts of this ridge.

Charley Bowman Pit.—West half northwest quarter section 15 (14 N., 3 W.). This deposit is located in a long ridge-like hill, which is associated with the morainic ridge. The hill is a kame.

Length of ridge with workable gravel........	400 feet
Width of ridge with workable gravel........	150 feet
Depth of gravel........................	30 feet

Section of Bowman Pit.

		Feet.
1.	Clay soil stripping..	3 to 5
2.	Brownish red sand and gravel..............................	1
3.	Stratified sand and gravel with pillars of cemented gravel.....	5
4.	Coarse stratified gravel with little sand.....................	12
5.	Gravel and sand, with sand in lenses.........................	10
6.	Layer of gravel with numerous granite boulders...............	2

This deposit contains excellent gravel for road work. The gravel has varying degrees of coarseness, the largest pebbles aver-

aging one inch in diameter. The color is light gray below and a brownish red above. It is quite free from clay and dirt, but in parts of the pit contains large amounts of sand. The pebbles are largely quartz, hornblendite, basalts, schists, and diorites, with some limestone and chert.

This pit has been opened for thirteen years. A large amount of gravel from it has been placed upon the National road. The pit is located right on the public road, is easily gotten to and worked. The bottom of the gravel can not be reached, since a large amount of the lower portions of the gravel is below ground water. The deposit is well located with reference to unimproved roads. Mr. Bowman strips the pit and keeps it in good shape, charging 10 cents per yard for gravel.

Deposit in Sections 10 and 3.—A large deposit occurs just north of the school house in section 3. Here is a long ridge which is underlain with gravel. The deposit has not been opened, as the Big Four pit is located just to the north.

M. Martin Deposit.—Southeast quarter section 31 (14 N., 3 W.). This deposit is located in the hills bordering Deer Creek.

Length of hill bearing gravel..............	300 feet
Width of hill bearing gravel...............	100 feet
Depth of gravel..........................	15 feet

The color is of a light gray below and a dark reddish above. A large amount of sand is associated with the gravel, there being only small pockets or lenses free from sand.

This deposit is located right on the public road and close to unimproved roads. There are several hills close to the one opened, that have not been opened. The owner strips the pit and sells the gravel to the county and township at the rate of 10 cents per yard.

Greencastle Township.

There is little gravel in Greencastle Township, save that found in the beds of streams. The township is underlain with limestone. Some gravel was located in the southeastern part of the township.

Montgomery Pit.—Southeast quarter section 36 (14 N., 4 W.). The deposit is located in the hills bordering Deer Creek. There

is a sufficiency of gravel here to gravel eight or ten miles of road, but the gravel is rather sandy and not of good quality.

Washington Township.

This township is well supplied with gravel in the southern and eastern parts. In the northern part bar gravel is largely used.

Joseph Hutchinson.—Northwest quarter southwest quarter section 11 (13 N., 5 W.). The gravel here occurs in an old cutoff of Big Walnut Creek.

Length of abandoned channel..............	200 feet
Width of abandoned channel..............	30 feet
Depth of gravel..........................	12 feet

The gravel is coarse, the pebbles averaging in size 1 to 1½ inches in diameter. Little dirt is present with the gravel. It is sold to the county and township at the rate of 15 cents per yard.

J. Trester Deposit.—Southeast quarter section 8 (12 N., 5 W.). The deposit here occurs in a long ridge like hill, bordering a tributary stream to Deer Creek.

Length of gravel bearing ridge...........	1,500 feet
Width of gravel bearing ridge.............	100 feet
Depth of gravel..........................	40 feet

This pit contains the best quality of gravel in the township. The gravel is of a light gray color, free from clay and dirt, is coarse throughout, except in places where pockets or lenses of sand occur. The pebbles are largely quartz, diorite, diabase, with numerous limestone pebbles and few sandstone.

The deposit is so located that it is easily gotten to, the pit being off the road about ¼ mile. Little stripping is required, and the entire deposit may be worked without interference of ground water.

The gravel wears well and is resistant to traffic. It cements well, making a smooth road bed. A road, upon which gravel from this pit has been used 3 years, was examined and found to be in excellent shape. The pit is stripped and kept in good condition by the owner, who charges the county and township 10 cents per yard.

Henry Barnett Pit.—Northeast quarter section 34 (12 N., 5 W.). The deposit is located in a high bluff bordering a tributary of Big Walnut. The gravel outcrops on the side bluff.

This is a large deposit, capable of graveling 20 miles of road.

Length of gravel bearing hill..............	500 feet
Width of gravel bearing hill................	125 feet
Depth of gravel.........................	30 feet

Section of Barnett Pit.

		Feet.	Inches.
1.	Clayey soil stripping..............................	2 to 3	..
2.	Reddish brown gravel and clay....................	....	8
3.	Gravel and sand rather coarse......................	8	..
4.	Gravel and sand rather sandy......................	5	..
5.	Stratified gravel and sand crossbedded.............	15	..
6.	Blue till at bottom.		

The gravel is a bluish gray color, is free from clay and dirt, and is of all degrees of coarseness. The pebbles are largely quartz, diabase, and diorite, with a large percentage of limestone.

The deposit is located right on the public highway, is easily gotten to and easily worked. All of the gravel may be worked, as it is above ground water. The gravel is sold to the township and county for 10 cents per yard.

J. Raab Pit.—Southwest quarter section 8 (13 N., 5 W.). This deposit is located along a tributary stream of Big Walnut.

Length of hill..........................	150 feet
Width of hill...........................	75 feet
Depth of gravel.........................	30 feet

Section of Raab Pit.

		Feet.	Inches.
1.	Clayey gravel stripping............................	2 to 3	..
2.	Reddish brown gravel.............................	....	8
3.	Coarse stratified gravel with some sand............	3	..
4.	Stratified sand and gravel..........................	15	..
5.	Cross bedded sand and gravel.....................	6	..
6.	Clay at bottom.		

The gravel is free from dirt and clay, is of a light gray color, and of different degrees of coarseness. The pebbles average ½ to 1 inch in thickness. Coarse lines of gravel often merge into fine gravel and even sand.

The gravel when placed upon the road cements well and wears evenly, the pebbles being tough. Most of that gravel now taken from the pit is used in the county on the county and township roads. The pit is located about 1/2 mile from the road, but is easily gotten to and close to unimproved roads. The gravel is sold to the county and township at the rate of 10 cents per yard.

Limestone Deposits of Putnam County.

Putnam County is well supplied with limestone. All of the important streams cut down to limestone rock. In certain portions of the county covered with the later drift, thick outcrops are not so frequent. The townships well supplied with limestone are Russell, Clinton, Monroe, Madison, Greencastle, Warren, Cloverdale and Jefferson.

Stone for road purposes was being crushed in Warren, Cloverdale, Marion, Russell and Greencastle townships. The formation universally used in the county is the Mitchell limestone of the Mississippian Epoch.

J. D. Torr Quarry.—Southeast quarter section 25, Madison Township. The limestone outcrops here along the side of a gully tributary to Big Walnut Creek. It is difficult to estimate the area, as it is covered with 12 to 14 feet of clay. Several acres are underlain with the rock.

The quarry is located about 3 miles west of Greencastle, on a switch of the Big Four Railway, so that cars may be loaded directly. The main traveled road runs close to the quarry, so that it is not a difficult matter to haul stone on to roads needing improvement.

Section of Torr Quarry.

		Feet.
1.	Clay soil stripping	12
2.	Light gray limestone in beds 2 to 4 inches in thickness	2
3.	Limestone in beds from 4 to 6 inches in thickness	3
4.	Dense bluish limestone nonfossiliferous	1
5.	Fine grained, compact, bluish limestone	4
6.	Dark blue, finely crystalline limestone	6
7.	Dark colored, finely crystalline, slightly fossiliferous limestone	8

Tests of samples made in the road laboratory of the U. S. Department of Agriculture resulted as follows:

*Results of Physical Tests of Mitchell Limestone from Quarry of J. D. Torr.**

Specific gravity	2.69	French coefficient of wear	10.34
Weight per cu. ft. (lbs.)	168.4	Hardness	14
Water absorbed per cu. ft. (lbs.)	.79	Toughness	11
Per cent. of wear	3.87	Cementing value—Dry	8
		Wet	24

"Rather high resistance to wear for limestone, but rather low cementing value. Should give satisfactory resu'ts under highway traffic."—Page.

Samples of the stone were analyzed by the chemist at the same laboratory, and the chemical constituents found to be as follows:

Analysis of Mitchell Limestone from Quarry of J. D. Torr.

	Per cent.
Alumina (Al_2O_3) and iron oxide (Fe_2O_3)	.80
Lime (CaO)	53.50
Insoluble in hydrochloric acid	2.77
Loss on ignition	43.00
Total	100.07

A large amount of stone from this quarry is used in the county. It is also shipped to Indianapolis and various points in Illinois.

The quarry is equipped with a crushing plant consisting of a No. 4 Gates crusher, bucket elevator, the stone being hauled from the bottom of the quarry to the crusher in small steel carriages, by means of a wire cable attached to a revolving iron cylinder. Twelve to 15 men are employed at the average wages of $1.75 per day. The crusher is capable of putting out 300 yards daily. The output for 1904 was 18,000 yards. The crusher has been in operation here for a period of about 25 years. Another crusher about ¼ mile east of Mr. Torr's has a capacity of 150 yards per day.

Several miles of road have been improved with material from this quarry. The road leading from Okalla to Greencastle, the county seat, was built from it in 1902. Examination of this road has shown the stone to possess good wearing as well as fair cementing qualities.

Simpson McGaughey Deposit.—Clinton Township. The limestone here outcrops in a bluff bordering a tributary of Little Walnut Creek for several hundred feet along the roadside and extends

*For standard of comparison see p. 79.

back several hundred feet under the hill. A well near by the outcrop was sunk 40 feet in limestone.

The deposit of stone is so located as to be easily accessible to all parts of the township. It could be easily worked, as there would be no need of working a deep quarry.

Section of McGaughey Quarry.

		Feet.
1.	Clay soil stripping	4 to 6
2.	A light colored limestone, with now and then patches of yellowish coloring, in beds 2 to 4 inches in thickness	3
3.	Very fine grained, light colored limestone, compact beds 2 to 6 inches in thickness	4
4.	A dark gray, finely crystalline limestone, with beds 12 to 18 inches in thickness	6
5.	Very fossiliferous, medium textured limestone at bottom near stream's edge. Numerous seams filled with silica.	

Samples tested at the road laboratory of the U. S. Department of Agriculture gave the following results:

*Results of Physical Tests of Mitchell Limestone from McGaughey Quarry.**

Specific gravity	2.63	French coefficient of wear	8.89
Weight per cu. ft. (lbs.)	165.3	Hardness	10
Water absorbed per cu. ft. (lbs.)	1.53	Toughness	8
Per cent. of wear	4.50	Cementing value—Dry	16
		Wet	20

"Sample gives about the average resistance to wear for limestone. Below average in cementing value. Should give satisfactory results."—Page.

A sample was analyzed at the same laboratory and showed the following chemical constituents:

Chemical Analysis of Sample of Mitchell Limestone from McGaughey Quarry.

	Per cent.
Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	55.25
Magnesia (MgO)	Trace
Phosphoric acid (P_2O_5)	.54
Insoluble in hydrochloric acid	.85
Loss on ignition	43.31
Total	99.95

J. B. Hillis Quarry.—Southeast quarter section 22 (14 N., 4 W.). This quarry, which is located about ½ mile southeast of

*For standard of comparison see p. 79.

Greencastle, is owned by J. B. Hillis. It has been in operation for several years. During this period a quarry 600 feet long, 300 feet wide, and about 30 feet deep has been made. It is situated in a little valley of one of the tributaries of Deer Creek.

Several acres are underlain with limestone. The foundation for the new court house at Greencastle rests upon the same formation, the stone coming to within 6 feet of the surface.

The quarry is well located for transportation. The Vandalia R. R. has built a switch up to the quarry so that the material can be loaded directly into the car.

Section of Hillis Quarry.

		Feet.
1.	Clayey soil stripping	4 to 6
2.	Thinly bedded, light gray limestone, in places highly colored with iron oxide	4
3.	Finely crystalline, dark gray limestone, beds 12 inches to 18 inches in thickness	5
4.	Thinly bedded, light gray limestone, beds 6 to 8 inches thick	4
5.	Thick bedded, bluish gray, finely crystalline limestone	6
6.	Light gray, slightly fossiliferous limestone	8
7.	Dark blue, compact, fine grained limestone at bottom.	

The results of tests made at the U. S. Road Laboratory were as follows:

*Results of Physical Tests of Mitchell Limestone from the Hillis Quarry.**

Specific gravity	2.7	French coefficient of wear	9.22
Weight per cu. ft. (lbs.)	168.4	Hardness	4.3
Water absorbed per cu. ft. (lbs.)	.43	Toughness	7
Per cent. of wear	4.34	Cementing value—Dry	13
		Wet	22

"Above the average in resistance to wear for limestone, but below in cementing value. Should give satisfactory results under highway and country road traffic."—Page.

A chemical analysis of the stone made at the same laboratory showed results as follows:

Chemical Analysis of Mitchell Limestone from the Hillis Quarry.

	Per cent.
Alumina (Al_2O_3)	.55
Lime (CaO)	55.2
Insoluble in hydrochloric acid	.12
Loss on ignition	43.40
Total	99.27

*For standard of comparison see p. 79.

Stone from this quarry is used for roads in the county, and for railway ballast is shipped into Illinois and other points. Several of the streets at Greencastle have been macadamized with stone from the Hillis quarry, and also several miles of road in the eastern part of Greencastle Township.

The crushing plant consists of a No. 4 Gates crusher with elevator and screen, and has a capacity of 150 to 250 yards per day. Stone is elevated from the quarry to the crusher by means of little steel carriages operated by machinery. About 20 men are employed daily.

Jerry Clifford Quarry.—Northwest quarter of the southeast quarter of section 32 (16 N., 5 W.), Russell Township. The limestone here outcrops in the bottom of a tributary stream of Raccoon Creek. This quarry was opened up in 1904. It has a face of 200 feet, a width of 75, and a depth of 15 feet.

Plate XI.

Quarry of Mitchell Limestone on land of Jerry Clifford, Russell Township, Putnam County.

Section of Clifford Quarry.

		Feet.
1.	Clayey soil stripping	2 to 3
2.	Light-colored, fine-grained limestone in thin slabs, 2 to 4 inches; in places oxidized	2
3.	Dark gray, thin-bedded limestone, beds being 4 to 6 inches	2
4.	Compact, dark gray, crystalline limestone	4
5.	Fine-grained, bluish-gray, slightly fossiliferous limestone	3
6.	Dark blue limestone at bottom, extremely hard.	

The tests made of this stone at the U. S. Road Laboratory resulted as follows:

*Physical Tests of Mitchell Limestone from Clifford Quarry.**

Specific gravity	2.67	French coefficient of wear	9.01
Weight per cu. ft. (lbs.)	165.3	Hardness	6
Water absorbed per cu. ft. (lbs.)	.99	Toughness	9
Per cent. of wear	4.44	Cementing value—Dry	16
		Wet	29

"Above the average resistance to wear for limestone. Only fair in cementing value. Should give satisfactory results."—Page.

Samples of the stone analyzed at the same laboratory showed the chemical constituents to be as follows:

Chemical Analysis of Mitchell Limestone from Clifford Quarry.

	Per cent.
Alumina (Al_2O_3) and iron oxide (Fe_2O_3)	.54
Lime (CaO)	53.65
Phosphoric acid (P_2O_5)	.16
Insoluble in hydrochloric acid	4.39
Loss on ignition	41.37
Total	100.11

The crusher used at the quarry is of the Gates type and capable of turning out 100 to 150 yards per day. Twelve men are employed to work in the quarry and run the crusher, and five to haul the stone on the road.

Six miles of road were built from this quarry in 1905. Where the roadway is properly graded and drained the stone will doubtless prove a lasting macadam material.

Putnamville Crusher.—Section 22, Warren Township. This crusher is owned by Mr. Ingler. It is moved from one to the

*For standard of comparison see p. 79.

other of two quarries which Mr. Ingler owns. Both quarries are on a small tributary of Deer Creek. The rock outcrops along the stream where the latter has cut a narrow gorge in the rock. The quarry has a face of about 100 feet and a depth of 15 to 20 feet.

Section of Ingler Quarry.

		Feet.
1.	Clay stripping	3 to 6
2.	Light gray, weathered limestone, colored more or less with iron oxide	3
3.	Light gray, finely grained, thinly bedded limestone	2
4.	Hard, compact, coarse grained limestone	3
5.	Bluish gray, finely crystalline, thick bedded limestone	6

No test was made of this stone, but a road was examined which had been built for a year. The stone cements well, makes a fairly smooth road bed, and wears quite evenly.

The stone crushed at the Ingler quarries is used largely in Warren Township. The Mitchell limestone has been quarried at Putnamville for flagstones and for building purposes. The crusher is a small one, being able to turn out 100 to 150 yards per day.

Quarries are found in Cloverdale Township, in sections 5 and 7, where stone has been taken out for use on roads. One also occurs in section 2, of Jefferson Township.

In Monroe Township stone suitable for macadam purposes occurs in quantity in sections 23, 26 and 35, along a tributary of Walnut Creek, and close to the C., I. & L. (Monon) Railway, which runs down the valley of the stream. The Mitchell limestone also occurs close to the surface in many places in the western half of the township.

HENDRICKS COUNTY.

Area in square miles	408
Population in 1900	21,292
Miles of public roads	820
Miles of improved roads	210
Percentage of roads improved	25.6
Miles improved with gravel	187
Miles improved with crushed stone	23
Average original cost of gravel roads per mile	$1,850
Average original cost of stone roads per mile	$2,683
Total original cost of improved roads	$407,659

Annual cost of repairs per mile on gravel roads 5 years old.......	$85
Annual cost of repairs per mile on stone roads 5 years old........	$60
Miles of improved roads (stone) built in 1905....................	7
Miles of improved roads (stone) contracted for 1906..............	13
Satisfaction of farmers with investment in improved roads.......	Good
Authority.................................	D. D. Mills, County Auditor

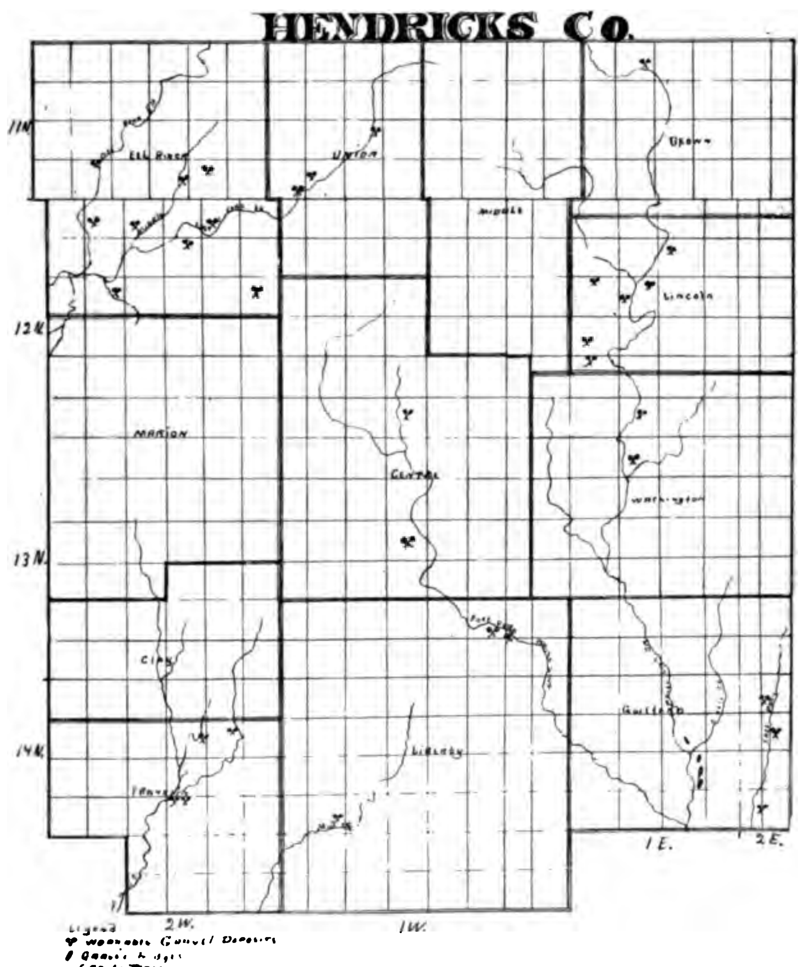

Fig. 44. Illustrating the distribution of road materials in Hendricks County.

Hendricks County is much smoother than Putnam, and is covered with the later drift, while Putnam has this drift only in its northern half. The roughest part of Hendricks is probably in the northwestern part, where we find the fading out of the re-

cessional moraine so prominent in Floyd Township, of Putnam County. This moraine extends to and a little beyond Danville, the county seat, around which the country is hilly. The county is deeply covered with the later drift, so that the streams in only a few places have cut down to bed rock. This occurs in Eel River Township, where in two places the river has cut down to the Knobstone shale, and also in Center Township, where the same shale is exposed along White Lick Creek. In all other parts of the county the streams have cut into the hard, blue till.

Most of the main traveled roads have been graveled and are in fairly good condition. There are a few miles of stone road in the western part of the county, where the gravel is difficult to obtain. Clay Township has few miles of graveled roads because of the scarcity of gravel.

Road Materials of Hendricks County.

As the county has no stone, gravel is extensively used. Not all parts of the county are well supplied with gravel. It is plentiful in Eel River, Lincoln, Franklin, and Guilford townships, but scarce in Brown, Middle, Union, Marion, Center and Liberty.

In several of the latter mentioned townships no pit gravel can be located. What is obtained is taken from the beds of the streams and must be pumped or dipped. This makes the total cost per yard high, as all dippers ask 30 cents per yard for dipping.

Eel River Township.

This township is well supplied with gravel. In nearly every case the gravel occurs in bluffs along streams.

D. C. Irwin Pit.—Northwest quarter section 17 (17 N., 2 W.). This deposit is located along the bluffs of Ramp Run.

Section of Irwin Pit.

		Feet.	Inches.
1.	Clay and soil	2 to 3	....
2.	Coarse reddish sand	......	6 to 10
3.	Cross-bedded gravel and sand	6	....
4.	Layer of fine sand—not continuous	......	4 to 6
5.	Gravel with thin seams of sand	8 to 10	....
6.	Till.		

The deposit is a large one, about 20 acres being underlain with gravel. The gravel is of a light gray color, free from dirt and clay. The size of the pebbles varies. In some parts of the pit coarse gravel may be had, while in others it is much finer. There are many pockets of coarse sand with pebbles averaging 1/8 of an inch in diameter. This is used extensively in North Salem for concrete. The gravel is about 80 per cent. quartz, with some limestone and chert.

The owner strips the pit and keeps it in good condition, charging in 1902, 10 cents per yard; in 1903, 15 cents per yard; in 1904, 15 and 20 cents; and in 1905, 15 cents. For concrete gravel which is used for bridge work the township and county pay 25 cents.

Not all of the gravel taken from the pit has been used in Eel River Township, as some has been hauled into Marion and Jackson townships. Over 6 miles of road has been graveled in Eel River Township, all in one stretch. It is often hauled 6 and 7 miles for repair work.

This is without question the best gravel in Hendricks County. A road built from it five years ago was examined and today is little the worse for wear. The road supervisor states that little repairing is necessary when the road is built of this gravel. It packs well, making a hard, smooth road bed, and exhibits excellent wearing qualities.

H. M. Baum Pit.—Northeast quarter section 10 (17 N., 2 W.), This pit is located in the edge of the moraine bordering East Fork of Eel River, which is here a long tongue-like ridge.

Section of Baum Pit.

		Feet.	Inches.
1.	Clay and fine sandy loam	1 to 2	..
2.	Fine sand	....	8
3.	Gravel and fine sand, alternating, the sand layers 1 to 2 inches thick	14	..
4.	Till.		

Length of ridge	300 feet
Width of ridge	50 feet
Height of ridge	20 feet

This gravel is not of the best quality for road purposes, as there is too much sand in it. It does not pack well on the road.

This gravel is now mostly used for repair work in Eel River Township. It is sold to the township at 15 cents per yard, the owner stripping the pit and keeping it in good condition. As the deposit is close to the main traveled road it is easily available.

J. A. Hadley Pit.—Center of section 4 (17 N., 2 W.). This deposit is located in the edge of a moraine, and is a kame. It is impossible to get to the bottom of the gravel on account of ground water.

Length	150 feet
Width	75 feet
Depth	15 feet

Section of Hadley Pit.

		Feet.	Inches
1.	Clayey loam	2 to 3	....
2.	Yellowish red sand and gravel	......	12 to 18
3.	Horizontally bedded sand and gravel	2	....
4.	Highly cross-bedded layers of sand and gravel	8 to 10	....
5.	Till.		

The gravel is of good quality, and packs well. There are certain areas in the pit where it grades into fine sand. The deposit is largely of quartz, the pebbles being well rounded.

About three miles of road has been graveled from this pit. At present it is used only for repair work, as most all of the roads of the township have been graveled. There is a variety that makes excellent concrete, so that much is being used for that purpose. This pit has been worked for 12 or 15 years. For road purposes the owner gets 10 cents per yard, and for concrete work 20 cents.

H. W. Davis Pit.—Southwest quarter section 5 (17 N., 2 W.). This deposit is located in an old terrace of a branch stream to Eel River. The gravel is about the same size and quality as that in the Hadley pit.

J. H. Fleece Pit.—Southeast quarter of southeast quarter section 32 (17 N., 2 W.). This large deposit is a part of the old terrace of the West Branch of Eel River, and is a river deposit of large size, there being about 5 acres underlain with good gravel.

Section of Fleece Pit.

		Feet.
1	Clayey loam	2 to 3
2	Reddish yellow sand and gravel	1 to 1½
3	Horizontally bedded layer of sand and gravel	2
4	Gravel interbedded with thin seams of sand and clay	16
5	Till.	

The upper portion of the gravel is of a reddish color, while lower down a bluish gray predominates. There is in certain parts of the deposit large amounts of fine sand and clay. The size varies in different parts of the pit, ranging from a very fine to a coarser, the pebbles of the coarser averaging ½ inch in diameter. The gravel packs well when placed on the road, as there is just enough clay around the pebbles to bind them together.

This pit is located right on the main traveled road so that it is easily available. Most of the material taken from this pit has been hauled into the northwestern part of the township. The pit is stripped by the owner, who charges the county and township 10 cents per yard for the gravel.

R. K. Speers Deposit.—Northwest quarter section 16 (17 N., 2 W.). There is a good deposit here, but it can not be worked as pit gravel on account of the water. The deposit is located in the creek bottom, and if used must be either pumped or dipped. This makes the gravel expensive, as it can not be dipped for less than 30 cents per yard, which added to the 10 cents paid to the owner of the gravel makes the cost per yard 40 cents.

James Trotter Pit.—East half of northwest quarter section 2 (17 N., 2 W.). This deposit is located in the old flood plain of East Fork of Eel River, now a terrace. The deposit is an exceedingly large one, covering 20 acres. The gravel outcrops along the edge of the terrace, but continues back into the farm land. This was determined by sinking holes at various places over the farm. Nowhere is the gravel covered with more than 3 feet of dirt. The cistern dug by Mr. Trotter at the house showed excellent gravel. A well was also sunk into the gravel.

Section of Trotter Pit.

	Feet.	Inches.
1. Clayey soil	1 to 1½	....
2. Yellow clay and gravel	......	10 to 14
3. Stratified gravel and sand	16 to 18	....
4. Hard blue till at bottom.		

The gravel is quite uniform in size, of grayish color, is clean and largely quartz. Throughout the pit there occurs large granite bowlders and now and then one of limestone.

Gravel from this pit has been placed in road district No. 2. A large amount is hauled into Union and Centre Townships. This

pit has been opened about 8 years. Several miles of road have been graveled. It is now largely used for repair work. A much traveled road built from this gravel 6 years ago was examined and found to be in excellent condition, showing little wear. As this pit is right on the public road, it should be used, for the gravel is of excellent quality.

Union Township.

Union Township is level and little cut up by streams. There is but little pit gravel in the township. What gravel there is, is located along the streams. Data gathered from wells in this region showed the drift to be very thick.

Deposit on Ed. White's Farm.—East half of northeast quarter section 28. This deposit is located in the bed of an old stream, which has been diverted from its old channel into a new one to the east.

By means of the auger the following estimates were made:

Length	600 feet
Width	15 feet
Depth	8 feet

The gravel will be rather difficult to get at, as there are 4 or 5 feet of clay to be removed. As the gravel is down to ground water here, it will probably have to be dipped or pumped, which will make the cost 30 to 40 cents per yard.

Pritchett Pit.—Southeast quarter section 31 (17 N., 3 W.). This deposit is located along the East Fork of Eel River, on the present flood plain. There is still a large supply of gravel here, but it is difficult to get at, as the gravel must be dipped. Two pits have been opened and all the gravel removed that could be by means of a steam dipper. Both pits were dipped to a depth of 25 feet. The owner charges 10 cents per yard for the gravel, but the township must pay 30 cents per yard for the dipping.

The gravel is of excellent quality, and makes good roads. It is of a light gray color, rather coarse, free from dirt, and is largely quartz. About 5 miles of road have been graveled from this pit.

John Leach Pit.—West half of section 32. This pit is on the same stream as the one last mentioned and must be worked in the same way. Little gravel has been taken from this pit, as it is difficult to get room to set the dipper.

Middle Township.

There is little available gravel in Middle Township, there being no pit gravel of any value. What has been placed on the roads has been taken from the beds of streams and hauled in from Brown Township.

Brown Township.

There is very little gravel to be had in Brown Township. Most of the gravel used in the township is hauled from Marion County on the east and Boone on the north, and from the bars along the streams in the township. During the last two years the streams have been high and bar gravel is abundant.

Rob Smith Pit.—Southeast quarter section 15 (17 N., 1 E.). This deposit is found on the bottom of a branch of White Lick Creek. The deposit is an extensive one, covering about 20 acres. The pit was first opened in 1870, and since that time more or less gravel has been taken out every year.

There is only one way of securing the gravel, and that is by dipping, as the gravel is below ground water. A stripping of 3 feet of clay is necessary before the gravel can be gotten at. The gravel is dipped by contract, so many yards for so much. The cost of the gravel to the township or county is 40 cents per yard.

The gravel is of excellent quality and makes good road beds. A road graveled about 20 years ago was examined and found still to be in fair shape. The gravel is free from fine sand and clay, is largely composed of quartz, and resistant to abrasion.

Lincoln Township.

The western part of Lincoln Township is well supplied with gravel. There is little in the eastern part. Although plenty of pit gravel may be had in the western part, a large amount of bar gravel is used. The main roads are mostly all improved, but gravel is needed for repair and for new roads opening up.

Alexander Arbuckle Pit.—Northwest quarter section 11 (16 N., 1 E.). This deposit occurs in the bluff bordering a branch of East Lick Creek.

Length	150 feet
Width	150 feet
Depth	10 feet

This gravel is not of excellent quality, as there is too much dirt and clay in it. The gravel is highly oxidized in places, and of a yellowish color. Farther down, near the base of the deposit, it is of a grayish color.

Near the stream's edge little stripping is necessary, but as the gravel is worked back into the hill more is required.

If the owner strips the pit the county or township must pay 25 cents per yard. If the township strips the pit 15 cents per yard is charged. This pit is located about 1/2 mile from the road.

Thomas Miller Pit.—Northwest quarter section 16 (16 N., 1 E.). This deposit is located along a small branch of White Lick Creek. It is in a valley train, and is one of the largest deposits in Lincoln Township. There is sufficient quantity of gravel here to improve 10 miles of road.

Section of Miller Pit.

	Feet.
1. Clayey soil	4 to 6
2. Fine loamy sand	1 to 1½
3. Gravel and sand cross-bedded	16 to 20

The gravel is of a light gray color, is free from dirt, contains little sand, and is of various sizes, some portions of the pit containing coarse gravel, other parts finer, and still others a fine sand. The sand occurs in pockets as does the clay. The pit is stripped by the owner, who sells the gravel to the township and county at the rate of 20 cents per yard. The gravel is easily gotten out and is located close to the main traveled road, so that transportation is easy. The bottom of the deposit has not been reached, but can not be worked on account of water interference. A rod was sunk some distance into the water and the bottom of the gravel was not reached. The deeper one goes the better the quality of the material.

This pit has been opened about 8 years. Some gravel has been hauled out every year. In the last two years several thousand yards have been hauled into Middle and Brown townships. It is now largely used for repair work.

John Hufford Pit.—West half of southwest quarter section 21. This pit is located in a high bluff bordering White Lick Creek and is of fluvial origin.

Length of ridge	600	feet
Width of ridge	150	feet
Height of ridge	15	feet

Section of Hufford Pit.

		Feet.
1	Yellow clay	4 to 6
2.	Gravelly clay	1
3	Gravel and sand	12 to 14

The gravel is of a reddish color at the top of the pit, while below it is of a grayish color. There is considerable clay throughout the deposit, the clay occurring in lenses and thin seams. There is also a large amount of fine sand. The gravel is coarser at top and finer at bottom. It is not very good for road purposes, as it does not pack well and cuts through quickly.

A. E. Hornaday Pit.—Section 15 (16 N., 1 E.). This deposit is similar to the above mentioned and of the same origin. This pit has been worked for several years, but not much gravel has been taken out lately. The gravel is limited in quantity and is of poor quality. It is too fine and sandy. There is probably 3,000 to 4,000 yards available, if stripped. The upper surface is covered with clay 6 to 8 feet thick.

Dave Doyal and Chas. Cummings Deposits.—Center of section 22 (16 N., 1 E.). These pits are not now worked as there is plenty of bar gravel along the branches.

The Doyal pit is opened, but the deposit on Mr. Cummings' farm has not been opened. Both deposits are close together and along the same branch of White Lick Creek.

Both deposits will furnish enough gravel to gravel 5 miles of road. There is one difficulty with these deposits and that is the stripping, both being deeply covered with drift.

The gravel is of good quality and makes good roads.

John Harlan Deposit.—Southwest quarter section 22 (16 N., 1 E.). Here is located a new deposit which has never been opened. It is in a high hill upon which sets Mr. Harlan's house. The whole hill is underlain with gravel.

J. H. Barlow Deposit.—Northwest quarter northeast quarter section 28 (16 N., 1 E.). There is a large sized deposit here which has not been opened.

This gravel is not of excellent quality, as there is too much dirt and clay in it. The gravel is highly oxidized in places, and of a yellowish color. Farther down, near the base of the deposit, it is of a grayish color.

Near the stream's edge little stripping is necessary, but as the gravel is worked back into the hill more is required.

If the owner strips the pit the county or township must pay 25 cents per yard. If the township strips the pit 15 cents per yard is charged. This pit is located about ½ mile from the road.

Thomas Miller Pit.—Northwest quarter section 16 (16 N., 1 E.). This deposit is located along a small branch of White Lick Creek. It is in a valley train, and is one of the largest deposits in Lincoln Township. There is sufficient quantity of gravel here to improve 10 miles of road.

Section of Miller Pit.

	Feet.
1. Clayey soil	4 to 6
2. Fine loamy sand	1 to 1½
3. Gravel and sand cross-bedded	16 to 20

The gravel is of a light gray color, is free from dirt, contains little sand, and is of various sizes, some portions of the pit containing coarse gravel, other parts finer, and still others a fine sand. The sand occurs in pockets as does the clay. The pit is stripped by the owner, who sells the gravel to the township and county at the rate of 20 cents per yard. The gravel is easily gotten out and is located close to the main traveled road, so that transportation is easy. The bottom of the deposit has not been reached, but can not be worked on account of water interference. A rod was sunk some distance into the water and the bottom of the gravel was not reached. The deeper one goes the better the quality of the material.

This pit has been opened about 8 years. Some gravel has been hauled out every year. In the last two years several thousand yards have been hauled into Middle and Brown townships. It is now largely used for repair work.

John Hufford Pit.—West half of southwest quarter section 21. This pit is located in a high bluff bordering White Lick Creek and is of fluvial origin.

Length of ridge	600 feet
Width of ridge	150 feet
Height of ridge	15 feet

Section of Hufford Pit.

		Feet.
1	Yellow clay	4 to 6
2.	Gravelly clay	1
3	Gravel and sand	12 to 14

The gravel is of a reddish color at the top of the pit, while below it is of a grayish color. There is considerable clay throughout the deposit, the clay occurring in lenses and thin seams. There is also a large amount of fine sand. The gravel is coarser at top and finer at bottom. It is not very good for road purposes, as it does not pack well and cuts through quickly.

A. E. Hornaday Pit.—Section 15 (16 N., 1 E.). This deposit is similar to the above mentioned and of the same origin. This pit has been worked for several years, but not much gravel has been taken out lately. The gravel is limited in quantity and is of poor quality. It is too fine and sandy. There is probably 3,000 to 4,000 yards available, if stripped. The upper surface is covered with clay 6 to 8 feet thick.

Dave Doyal and Chas. Cummings Deposits.—Center of section 22 (16 N., 1 E.). These pits are not now worked as there is plenty of bar gravel along the branches.

The Doyal pit is opened, but the deposit on Mr. Cummings' farm has not been opened. Both deposits are close together and along the same branch of White Lick Creek.

Both deposits will furnish enough gravel to gravel 5 miles of road. There is one difficulty with these deposits and that is the stripping, both being deeply covered with drift.

The gravel is of good quality and makes good roads.

John Harlan Deposit.—Southwest quarter section 22 (16 N., 1 E.). Here is located a new deposit which has never been opened. It is in a high hill upon which sets Mr. Harlan's house. The whole hill is underlain with gravel.

J. H. Barlow Deposit.—Northwest quarter northeast quarter section 28 (16 N., 1 E.). There is a large sized deposit here which has not been opened.

Washington Township.

Gravel is scarce in this township. Most of the gravel used on the roads has been obtained from the beds of the streams in the township. All of the principal roads of the township have been graveled, but some need repairing.

Interurban Gravel Pit.—Southwest quarter section 3 (15 N., 1 E.). This deposit was discovered while grading through a bluff east of Danville. The deposit is a large one, the company buying up about 20 acres of land, all of which was underlain with gravel. Little of this will be available for road purposes.

Centre Township.

There is little gravel in Centre Township except the bar gravel along the streams. The gravel used upon the roads is taken from the bed of East White Lick Creek and its branches.

E. and S. Kiger Pit.—Southeast quarter section 34 (15 N., 1 W.). The gravel outcrops along a steep bluff of East Lick Creek.

Length of outcrop........................	200 feet
Width of outcrop........................	50 feet
Depth	15 feet

The gravel is of a grayish color, is rather fine, and contains much sand. It does not make good road material, and is used mostly for repair work.

Marion Township.

There is little gravel in Marion Township outside of that found in the bed of streams. Gravel is hauled from Eel River Township and from Putnam County. All the main traveled roads have been graveled. A knob sandstone outcrops near New Winchester. A mile or two of road has been made from this stone and then covered with gravel.

Clay Township.

The beds of the East, Middle and West Forks of Mill Creek are rich in gravel. There is no pit gravel. Gravel may be pumped or dipped almost any place along these streams. Seams of from 15 to 20 feet are common. Gravel has been pumped in

sections 10 and 12 (14 N., 2 W.), on the farms of Miles West and Enery Mosten. Several miles of road were built from gravel from these two farms. The gravel is not of good quality, as it is too fine and there is too much sand in it.

Where the township owns the pump, the gravel costs 10 cents, but where it is owned by private parties the gravel costs the township 20 cents.

In the western part of the township gravel is hauled from the Big Four Pit in Putnam County. The improved roads of Clay are graveled.

Franklin Township.

But little graveling has been done in Franklin Township. The southern part has little gravel, so that the roads are in bad condition. There is now a petition before the county for improving 17 miles of road.

The knob sandstone outcrops in several places along Mill Creek, but the stone is of no value for road purposes, as it is too soft and friable. The northern part of the township has sufficient gravel.

John Walls Pit.—Northwest quarter section 22 (14 N., 2 W.). This deposit is of glacial origin, and consists of a long, elevated ridge extending in a northeast and southwest direction, from where the public road entering Stilesville crosses Mill Creek to the town of Stilesville.

Length of ridge on land of Mr. Walls......	1,000 feet
Width of ridge on land of Mr. Walls.......	150 feet
Depth	20 feet

Section of Walls Pit.

		Feet.
1.	Clay and soil..	2 to 4
2.	Reddish sand	1
3.	Gravel and sand..	15 to 20
4	Boulder till.	

This gravel is not of the best quality, as there is too much sand and dirt in it. There is also present a large percentage of sandstone pebbles. The gravel is fine, the pebbles averaging ¼ inch in diameter. There are certain portions of the pit where the gravel is coarser.

This pit was opened 30 years ago, and the Stilesville and Greencastle road was improved from it. Only about 3 miles of road in Franklin Township has been graveled. The gravel taken from here costs the county and township 5 cents per yard.

O. E. Hume Deposit.—Northwest quarter section 22 (14 N., 2 W.). This deposit is but a continuation of the ridge above mentioned. It has not been opened, but may be when necessary. It is a large deposit.

McHaffie Pit.—Southwest quarter section 22 (14 N., 2 W.). This pit was opened one year ago and 2,000 yards of gravel taken out. It is no longer used because the gravel is too fine and sandy and of little value for road purposes.

Liberty Township.

The southern part of the township gets most of its gravel from the bed of Mud Creek. Little gravel could be located in the central part of the township. In the northeastern part gravel occurs in section 25, along the west fork of White Lick Creek.

Deposit in Section 25 (14 N., 1 W.). This deposit is located in the ridge of hills to the north of the main traveled road from Plainfield to Danville. It has not been opened, but the gravel may be seen outcropping in the side hill. Examination was made and it was found that the whole hill for a distance of several hundred feet was underlain with gravel which is of fair quality but contains a large amount of fine sand. By screening a good supply could doubtless be obtained.

This deposit is well located with reference to unimproved roads. It could be easily worked, as the gravel now outcrops in the side hill.

Deposit North of Cartersburg.—Section 25 (15 N., 1 W.). Gravel outcrops in the bluffs bordering the East Fork of White Lick Creek, just where the road leading from Danville to Cartersburg crosses the bridge. The deposit here is of good size and good quality.

Guilford Township.

This township is well supplied with gravel. Very few pits are worked, but gravel is obtained from the beds of the streams. White Lick Creek is rich in bar gravel. South of Plainfield gravel may be obtained from the bed of White Lick Creek at

almost any place. Excellent bar gravel was located in sections 23, 14, 11, 2 and 34.

The East Fork of White Lick Creek is equally rich in bar gravel. Large deposits were also located in the prominent ridge of hills to the east of White Lick Creek in sections 14, 11, and the north half of 23. Also in sections 8 and 17 along the East Fork of Lick Creek. In both cases the hills were carefully examined and gravel was located in the ridges.

Abe Hoadley Pit.—Southwest quarter section 19 (14 N., 2 E.). This deposit occurs along a branch of White Lick Creek, and is a river deposit.

Length of hill........................	500 feet
Width of hill.........................	75 feet
Depth of gravel.......................	15 feet

Section of Hoadley Pit.

		Feet.	Inches.
1.	Clayey soil stripping...........................	2 to 4	....
2.	Fine loamy sand	....	6 to 12
3.	Gravel and sand highly oxidized.................	2 to 3	....
4.	Stratified, rather coarse gravel.................	3	....
5.	Stratified sand and gravel.......................	6	....
6.	Blue clay at bottom.		

The color ranges from a reddish brown above to a yellowish gray below. In places the gravel is highly oxidized, being of a deep yellow color. Sand occurs in pockets or lens like masses. Some clay is present throughout the deposit, but occurs in pillar like masses. Iron oxide is largely the cementing principle. The pebbles are largely quartz, diabase, diorite, and hornblendite, with a few of sandstone and limestone present.

A large amount of gravel from this pit has been hauled into Monroe Township, Morgan County. Several thousand yards have been used on the roads in Guilford Township. The pit has been worked for several years. A road was examined which had been graveled from this pit several years ago. The road, where well graded before the gravel had been placed on, was in excellent condition, the gravel having packed well, making a smooth, hard roadbed. The owner strips the pit, charging the township and county 10 cents per yard for the gravel. The pit is easily stripped and worked, since there is no interference of ground water, the deposit being located on the top of the blue clay.

MARION COUNTY.

Area in square miles	400
Population in 1900	197,227
Miles of public roads	1,190
Miles of improved roads	800
Percentage of roads improved	67.2
Miles improved with gravel	800
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,100
Total original cost of improved roads	$880,000
Annual cost of repairs per mile on gravel roads 5 years old	$75
Miles of improved roads (gravel) built in 1905	25
Proportion of improved roads built since 1895 (per cent.)	70
Satisfaction of farmers with investment in improved roads	Good
Authority	Cyrus J. Clark, County Auditor

Marion County is quite undulating except in the northern and western parts. The only terminal moraines in the county are in the northwestern part, in Pike and Washington townships, and in the southern part in Perry, Decatur and eastern Warren townships. The West Fork of White River extends through the entire county from north to south in a wide valley, bordered on both sides by prominent ridges. The drift is from the later or Wisconsin ice sheet, and is exceedingly deep, so that no stream reaches bed rock.

Nearly all the locations of gravel made were confined to three morainic ridges in Pike, Washington, Perry, eastern Wayne, eastern Decatur, eastern Franklin, and Warren townships. A large gravel plain borders White River, so that gravel may be obtained in the river valley at a depth of from 3 to 10 feet. This gravel could only be removed by dipping or pumping. Nearly the whole of Centre township, in which Indianapolis, the county seat and state capital is situated, is underlain with gravel.

The cellars of many houses were examined, and all had to be walled, as the gravel would cave in.

Roads of the County.

In general, the roads of Marion County are in good shape, nearly all of the important roads having been graveled. This county is better supplied with gravel in all parts than either Putnam, Hendricks, or Morgan. There are no steep ridges or

extremely rough surfaces over which important roads must go, so that the problem of road improvement is not so difficult.

Seven miles of stone road have been built, the crushed stone having been sent in from Putnam County, where stone is plentiful.

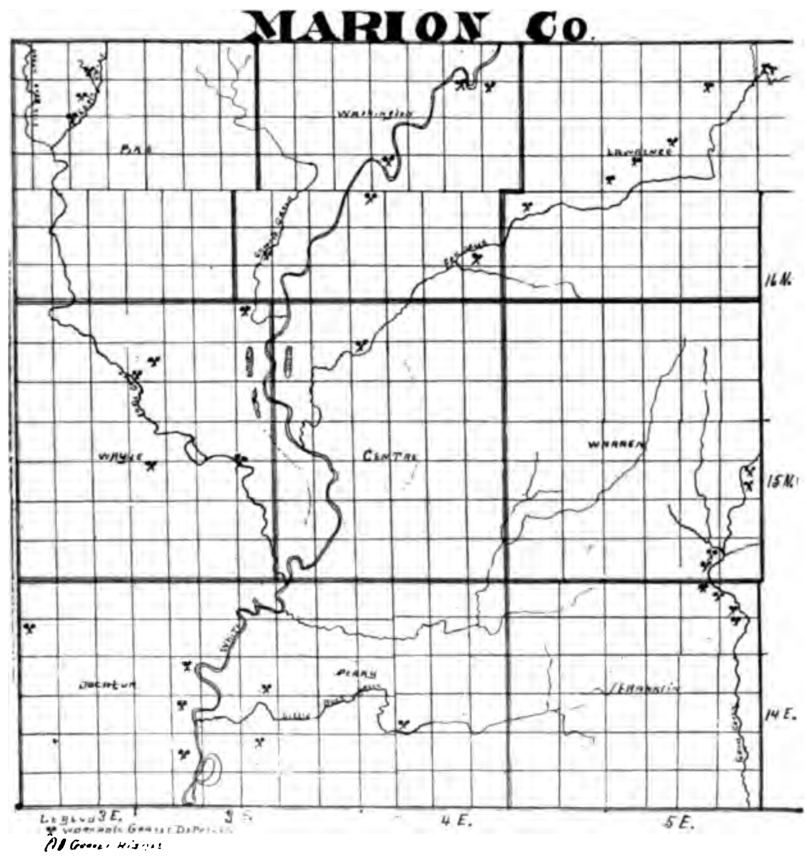

Fig. 45. Illustrating the distribution of road materials in Marion County.

Parts of the Cobland Pike have been stoned and gravel placed over it. There is no stone in Marion County, so that the stone used must be shipped in. Marion County has 400 miles of fine graveled roads, constructed at a cost of $850 per mile.

Pike Township.

This township is well supplied with gravel in the western part, but there is little in the eastern part. Gravel is plentiful along

Eagle and Fishback creeks. In the eastern part of the township the gravel used comes from the beds of Crooked and Little Eagle creeks.

James Eudaly Pit.—Northeast quarter section 28 (17 N., 2 E.). This deposit is found in the old terrace of Eagle Creek, and is of glacial origin.

Length	100 feet
Width	30 feet
Depth	15 feet

Section of Eudaly Pit.

		Feet.	Inches
1.	Clayey loam	1 to 2	....
2.	Gravelly clay	....	10 to 12
3.	Coarse stratified gravel	2 to 3	....
4.	Gravel and sand	4	....
5.	Coarse gravel with thin seams of sand and clay	5	....
6.	Blue till.		

The gravel is of a light gray color, rather coarse in places, free from soft pebbles, and clean, as great care has been used in stripping. Most of the gravel taken from this pit is used in Pike Township. Some has been hauled into Brown Township, Hendricks County. This pit has been opened three years, and most of the gravel now taken from it is being used for repair work. This deposit is located right on the road and is easily gotten at. The owner strips the pit and keeps it in good condition, charging 15 cents per yard for the gravel.

Moor Talbott Farm.—Section 22 (17 N., 2 E.). This deposit occurs in a high hill bordering Eagle Creek. This hill is continuous through sections 22 and 15, with numerous places where gravel may be obtained.

Mr. Talbott's deposit has not been opened, but may be if needed. It is a large deposit and sufficient in quantity to build several miles of good road.

Washington Township.

The central part of Washington Township is quite rough, having in it two morainic ridges, while the western and eastern portions are smoother. While there is considerable pit gravel, a large amount of the gravel used on the roads is hauled from

White River. Pit gravel is plentiful along Fall and Crooked Creeks.

Broad Ripple P. O.—Northeast quarter of northeast quarter section 36 (17 N., 3 E.). Here is a very wide channel of the White River, made shallow by damming up of the main channel and sending water down the hydraulic main. This channel is filled with excellent gravel. It is easily gotten out, as the teams drive into the channel and scoop up the gravel.

Deposit in Northeast Quarter Section 1 (16 N., 3 E.).—This deposit has not yet been opened. It is located in the second river terrace, and is a large deposit.

Deposit in the Northeast Quarter and Northwest Quarter Sections 20 and 21 (17 N., 4 E.).—These deposits have not yet been opened up, but may be with little expense, as the gravel occurs in the terrace bordering the river on the present flood plain. It would be impossible to reach the bottom of the gravel here without dipping, as it goes below the present river level.

Pit in the Southwest Quarter Section 9 (16 N., 4 E.).—This deposit occurs in a morainic ridge bordering Fall Creek. The stream has cut up against the bluff so that the gravel outcrops in a steep cliff. This is an extremely large deposit, as shown by the following dimensions:

Length of hill	300 feet
Width of hill	100 feet
Height of hill	40 feet

Section of Pit in Southwest Quarter Section 9 (16 N., 4 E.).

		Feet.	Inches.
1.	Clayey soil	1 to 2	......
2.	Fine loamy sand	......	2 to 8
3.	Gravel with thin seams of sand	2 to 4	......
4.	Cross-bedded gravel and sand cemented in large blocks	6 to 10	......
5.	Gravel with pockets of sand	4 to 6	......
6.	Blue clay.		

The gravel from this pit is fine in certain horizons and coarser in others. The average size pebble is one-half inch. About 70 per cent. are quartz, with quite a large percentage of limestone. In places the gravel merges into sand pockets. Thin layers of

clay are interbedded with the gravel. Where stripped carefully the gravel contains little dust and dirt.

This gravel packs well and resists abrasion. One road was examined where the gravel had been on for two years, and the roadbed was hard and even, showing the equal wearing of the gravel. The pit is stripped and kept in good condition by the owner, who charges 15 cents per yard. Most of the gravel is used in southeastern Washington and southwestern Lawrence townships.

Deposit in Northwest Quarter Section 27 (17 N., 3 E.). The gravel occurs here in a high bluff-like ridge bordering Crooked Creek.

Length of outcrop	600 feet
Width of outcrop	100 feet
Depth of outcrop	12 feet

Section of Pit on Crooked Creek.

		Feet.
1.	Clay	1 to 3
2.	Gravelly clay	1
3.	Gravel with numerous layers of sand and clay	10
4.	Blue clay.	

This gravel contains large quantities of fine sand and clay. The better gravel runs in pockets or lenses, and is a dark gray in color. A number of large stones are present. This gravel is not the best for road purposes.

Lawrence Township.

The northeast and north central parts of the township are well supplied with gravel, while in the southern and northwestern little gravel is to be had. Some bar gravel is obtained from the bed of Indian Creek, west of Oaklandon.

Gravel for the southeastern part is hauled from Warren Township, while the west is supplied from Washington.

Wilson & Hill Pits.—Southwest quarter section 15 (17 N., 5 E.). The gravel is here located in the bluff bordering North Fork Creek, and is of fluvial origin.

Length of gravel-yielding bluff	300 feet
Width of gravel-yielding bluff	175 feet
Depth of gravel	15 feet

Section of Wilson & Hill Pits.

		Feet.	Inches.
1.	Clayey soil	1 to 1½	....
2.	Clayey gravel, oxidized	......	6
3.	Gravel and sand	1	....
4.	Very coarse gravel, pebbles 2 to 4 inches in diameter	......	12 to 18
5.	Gravel with thin seams of sand	12	....
6.	Clay at bottom.		

At top the gravel is of a yellowish color, having been oxidized. Some distance from the top the gravel is of a grayish color. It is not uniform in size, there being certain horizons where the gravel is too coarse for road purposes. There are a number of large boulders in the pit. The pebbles are flattened and well rounded, showing them to be of river origin. This gravel does not pack well when placed on the road, as it is too coarse and contains too much sand. The gravel is sold to the township at the rate of 15 cents per yard. The expense of stripping is slight, and as the pit is situated on the road the cost of transportation is slight.

Ringer Pit.—Northeast quarter section 20 (17 N., 5 E.). This is a small deposit and would scarcely pay for the working, as the gravel is covered with a heavy stripping of clay, about 8 feet of which must be removed. The gravel is of poor quality, of a reddish color, and contains a large percentage of clay.

Deposit in Southwest Quarter Section 30 (17 N., 5 E.). Here along the roadside, in a steep ridge bordering Fall Creek gravel was seen to outcrop. A careful examination of the hill showed the deposit of considerable size. This deposit might be opened with little trouble, as it is right on the road and therefore easily available.

Gravel Pit in Section 36 on U. S. Reserve (17 N., 4 E.). The gravel outcrops along the upper river terrace and is of river origin. The terrace here is quite broad and extends for one-half mile. Several acres are underlain with gravel.

Section of Pit on U. S. Reserve.

		Feet.	Inches.
1.	Clayey loam	3	..
2.	Reddish gravelly clay	1	..
3.	Gravel and sand highly stratified	12	..
4.	Fine sand	..	2
5.	Blue clay.		

This gravel is not of the best for road purposes. Too much sand and clay are present, and the gravel is too fine. The upper portion is oxidized and is of a reddish brown color. The lower portion is of a light gray color. The material does not pack well on the roads, the wheels of vehicles soon cutting through it. It is sold to both the county and township at 15 cents per yard.

C. A. Schofield Pit.—Northwest quarter section 2 (16 N., 4 E.). This pit has been opened on Fall Creek bottom near the stream. Gravel has been taken from the pit for concrete work, but little has been placed on the road. The deposit here is not large, there probably being but 4,000 or 5,000 yards available.

Center Township.

Center Township has an abundance of gravel, both pit and bar. The whole western border of the township has a plentiful supply in the high bluffs to the west of White River. Indianapolis is located on the old flood plain east of the river, and is everywhere underlain with gravel. In digging cellars and water mains in the city gravel is struck after one or two feet of stripping has been removed.

Gravel is dipped by steam dippers from Fall Creek at numerous points for street car lines and other purposes. On the map I have outlined the main gravel deposits along the river.

Warren Township.

Little gravel is to be found in northern and central Warren. In the west gravel is taken from the bed of Pleasant Run. In the southeastern part of the township along Grass Creek, large quantities of gravel are located. All of the roads have been graveled, but some need repairing.

Harris Deposit.—Southeast quarter section 16 and northeast quarter section 21 (15 N., 5 E.). This deposit occurs in Grass Creek bottom and the gravel must be dipped, as the water level comes very near the surface.

About 100,000 cubic yards are available. Three or four acres are underlain with gravel. Mr. Harris owns a dipper and dips the gravel for the township and county, charging them 35 cents per yard.

John Kitley Pit.—Southeast quarter of section 21 (15 N., 5 E.). This deposit occurs in the second terrace along Grass Creek, and is of large size, several acres being underlain with a seam of gravel 12 to 14 feet thick.

Section of Kitley Gravel Pit.

	Feet.	Inches.
1. Sandy loam		12 to 14
2. Clayey gravel		14
3. Gravel with thin layers of sand from 1 to 2 inches in thickness	12	....
4. Clay.		

The seam of gravel alternates with a seam of sand. The gravel is not all of the same degree of coarseness. Masses of clay are prominent in different parts of the pit. The gravel is largely quartz, with limestone and chert present. It is mixed with much sand, so that when placed on the road it does not pack well.

This pit is easily gotten at and worked, since the gravel can be gotten out without interference of water. The owner strips the pit and gets 20 cents per yard for the gravel. A large amount of it has been used in the township and large quantities have also been hauled into Hancock County. The interurban street car line has used several thousand cubic yards.

Reynolds Pit.—Northeast quarter of section 28 (15 N., 5 E.). This pit is pretty well exhausted. It is a very shallow deposit, occurring in the second terrace of Grass Creek. Not more than 3,000 yards of workable gravel remain.

Franklin Township.

Franklin Township is quite level in the western and central, but rolling in the eastern part, where several quite prominent morainic ridges are present, bordering on Grass Creek.

Almost all of the gravel of the township occurs in the ridges and on the creek bottoms. Very little can be located in the western part. All the principal roads of the township have been graveled.

J. H. Meyer Deposit.—Northwest quarter and southwest quarter of sections 34 and 35 (15 N., 5 E.). Mr. Meyer has not yet opened this deposit. By prospecting, it was found that an area of 4 or 5 acres was underlain with gravel, which must be dipped, as it can be worked in no other way.

W. H. and C. M. Harris Pit.—Northeast quarter section 28 (15 N., 5 E.). This large deposit is in the present flood plain of Grass Creek. The only way that the gravel can be gotten out is by dipping. This makes the gravel cost the township 35 cents per yard. Mr. Harris owns a dipper and in 1904 dipped 8,000 cubic yards. There is still available 50,000 yards. The seam of gravel is from 25 to 30 feet deep.

This gravel is of excellent quality. It is clean, free from clay, largely quartz, and averaging one-half inch in diameter. A road examined upon which the gravel had been placed in 1903 showed it to be of excellent wearing qualities.

Bauser Pit.—Northeast quarter section 28 (15 N., 5 E.). This deposit occurs in a high ridge bordering Grass Creek. The gravel outcrops just below the barn, and by prospecting I found the entire hill underlain with gravel.

Perry Township.

The west half of Perry Township is quite rough, there being a prominent morainic ridge along the river. The eastern part is gently rolling.

In the western and central parts of the township gravel is plentiful, being found in the morainic ridge and in the river plain. In the southeastern, little gravel could be located. Some of the largest and finest deposits in the county occur in this township.

H. Arms Pit.—West half of section 15 (14 N., 3 E.). This deposit is but a part of a much larger one, which is continuous in the form of a ridge throughout the section. The ridge is a sub-glacial deposit. It is quite prominent, reaching up above the valley plain to a distance of about 60 feet. This pit is practically unlimited in supply, as the entire ridge is of gravel. No stripping is required, as the gravel comes to the surface on the top of the ridge. The gravel here, where opened, is of poor quality, there being too much sand and dirt mixed with it. But little of this gravel has as yet been placed upon the roads.

Clark Sutton Pit.—Southeast quarter section 21 (14 N., 3 E.). Mr. Sutton's pit is but a continuation of this same ridge above mentioned. This ridge extends through sections 11, 10, 15, 22 and 21 (14 N., 3 E.). The general direction is northeast and southwest.

This is an extremely large deposit, probably the largest in Perry Township.

Length of ridge........................	½ mile
Width of ridge........................	200 feet
Height of ridge........................	50 feet

Section of Sutton Pit.

		Feet.	Inches.
1.	Sandy loam	..	6 to 10
2.	Reddish brown gravel	..	18
3.	Gravel and sand cross-bedded	40	....

This pit shows cross-bedding to a high degree. Certain lenses of gravel will run into coarse sand and then into gravel again. This is the best deposit in the county, the gravel is of good size, is free from dirt and clay, is of a light gray color, and well-rounded pebbles. There are few soft stones present, the largest percentage being quartz pebbles.

This pit was opened up in 1875, and the road from Glenn Valley to Indianapolis was graveled from it. A large amount of the gravel is used on the county and township roads in the township. Some is hauled into Johnson County. It is now used also for concrete work. This deposit is located right on the main traveled road, so that it is easily available. Little stripping is necessary, so that the pit may be kept open at small expense. Gravel is sold at 8 and 10 cents per yard to both county and township.

Roads examined upon which this gravel has been for some years prove it to be of the best. The gravel packs well, making a smooth, hard roadbed. Being so largely of one kind of mineral —quartz—it wears evenly.

W. M. Wishard.—North of the center of section 16 (14 N., 3 E.). This deposit is located in the present flood plain of White River, but is not used at present, as it is impossible to get the gravel out of the water without dipping. About six miles of road have been graveled from this pit. The gravel seam is from 25 to 30 feet thick.

William Hamilton Pit.—Southeast quarter section 4 (14 N., 3 E.). Mr. Hamilton's deposit occurs in a terrace of a small tributary to White River and is of river deposition.

Length of opened deposit................	60 yards
Width of opened deposit................	40 yards
Depth of opened deposit................	12 feet

There is an unopened deposit right south of Mr. Hamilton's house of the same size.

Section of Hamilton Pit.

	Feet.	Inches.
1. Clayey sand	..	6 to 12
2. Gravelly sand	..	6 to 8
3. Gravel, coarse, oxidized............................	4	....
4. Gravel, finer, interstratified with sand..............	5	....
5. Boulder clay.		

The color of the gravel at the top is yellowish brown, while below it is of a bluish gray color. The upper part is very coarse, while the lower is finer. Cobble stones make up about 70 per cent. of the upper part of the deposit. The gravel is quite free from dirt. Limestone forms about 20 per cent. of the deposit. The gravel needs little stripping, as it outcrops at the surface. The owner strips the pit and charges 20 cents per yard. Most of the gravel hauled out is used in the township for repair of the roads, about 800 cubic yards having been taken out in 1905 for this purpose.

Jordan Pit.—Northwest quarter section 11 (14 N., 3 E.). This deposit has not been opened for road purposes. The Indianapolis Southern Railway passes through Mr. Jordan's farm, and it was while cutting through this ridge, upon which a nursery is located, that the gravel was discovered.

The ridge is a prominent morainic ridge, extending in a northeast-southwest direction, and is a part of the same ridge already mentioned. After some prospecting, it was found that this entire ridge is made of gravel and sand, and is probably of subglacial water deposition.

The ridge on Mr. Jordan's farm is about one-fourth of a mile long, 100 to 150 feet wide, and 30 to 40 feet high. In certain parts the gravel comes near the surface, while in other places a covering of from 4 to 5 feet of clay is found.

On Mr. Jordan's farm is a well, which was sunk at the bottom of the ridge, 35 feet in gravel and sand. Judging from this the gravel must go down 40 or 50 feet.

In the cut made by the new railway the gravel was exposed. It is of excellent quality for road purposes, being free from clay, with little sand, and largely quartz.

The sand runs in pockets; a gravel seam often grades into sand. The railway company is considering the question of buying 10 acres of Mr. Jordan in order that they may obtain gravel for ballasting their new roadbed.

Decatur Township.

Decatur Township is quite rolling in the northwestern and extremely so in the southeastern, where a morainic ridge is quite prominent. In the ridge are numerous gravel deposits. The eastern part of the township is well supplied with gravel, while little could be located in the western and northern portions.

Starbreech Pit.—Northwest quarter section 33 (15 N., 2 E.). The deposit here is located on a high hill bordering East Lick Creek.

Length of hill	300 feet
Width of hill	60 feet
Height of hill	20 feet

Section of Starbreech Pit.

		Feet.
1.	Clay	1 to 4
2.	Stratified sand with little gravel	1
3.	Gravel with thick seams of clay and sand	18
4.	Boulder clay.	

The gravel is not of good quality, as there is too much clay and sand present. Large masses of clay occur throughout the deposit. Many large limestone boulders are also present.

This pit is not now worked, but has been worked extensively, several thousand yards having been taken out.

John E. Smith.—Northwest quarter section 7 (14 N., 2 E.). This deposit is located in the banks of a tributary to White River. There are probably 5,000 to 8,000 cubic yards available. Little stripping is necessary, as the gravel comes very near the surface. This pit has not yet been opened, but may be if necessary. The deposit is well located for easy transportation to the central part of the township.

Newman Pit.—Northeast quarter section 6 (14 N., 2 E.). This deposit is located in the second terrace of White River. It is of river deposition. Several acres are underlain with gravel, which is of a light gray color, rather coarse and free from clay and dirt. It contains some limestone, and packs well when placed on the road. The gravel is sold at the rate of 10 cents per yard to the county and township. Most of it is used in the township. This pit was opened 25 years ago, and roads built from it are yet in good shape.

E. Lane Pit.—Southwest quarter section 18 (14 N., 2 E.). This deposit is located in the morainic ridge bordering the river. The gravel from it is not used, as it is too sandy. The deposit is an extremely large one, but not of good quality.

Wayne Township.

Wayne Township is well supplied with gravel in the eastern and central portions, but little gravel is to be had in the western part. Gravel is obtained from the bed of Eagle Creek and White River. In the northeast part of the township pit gravel is plentiful.

J. J. Cooper Pit.—Northwest quarter section 21 (16 N., 3 E.). There is a ridge extending through sections 21 and 28, along White River, which is underlain with gravel. This deposit is extremely large, several acres being underlain with gravel.

Section of Cooper Pit.

	Feet.	Inches.
1. Clay soil	2 to 4	....
2. Sand and gravel, reddish brown	......	6 to 10
3. Stratified gravel and sand	14 to 16	....

The gravel occurs in lenses, no seams being continuous, the gravel merging into sand, and the sand into gravel. Often pockets of fine sand occur. Where the gravel can be gotten, free from sand, it is of excellent quality, being light bluish gray in color, largely quartz, with some limestone.

MORGAN COUNTY.

Area in square miles	415
Population in 1900	20,457
Miles of public roads	500
Miles of roads improved	140
Percentage of roads improved	28
Miles improved with gravel	100
Miles improved with crushed stone	40
Average original cost of gravel roads per mile	$900
Average original cost of stone roads per mile	$1,700
Total original cost of improved roads	$158,000
Annual cost of repairs per mile on gravel roads 5 years old	$50
Annual cost of repairs per mile on stone roads 5 years old	$50
Miles of improved road (gravel) built in 1905	17
Miles of improved road (stone) built in 1905	12
Miles of improved road (gravel) contracted for 1906	14
Miles of improved road (stone) contracted for 1906	5
First improved roads built	1860
Proportion of roads improved since 1895 (per cent.)	50
Satisfaction of farmers with investment in improved roads	Good
Authority	B. R. Johnson, County Auditor

Morgan County is level in the northwestern part, while in the central, southern and southwestern portions it is hilly and broken. In the northern part, we find the later drift exceedingly thick, while in the central and southern portions we have the hills covered but thinly with the earlier or Illinoian drift.

The central part of the county is traversed by the valley of the White River, which at its widest point in the county reaches a width of two miles. This valley is bounded on both sides by high hills, some reaching an elevation of over 100 feet.

Morainic ridges are prominent. In the southeastern, a ridge extends from Martinsville, the county seat, in a southeast direction to Morgantown. In the northeast a ridge is prominent through Harrison, southern Madison and northwestern Green townships. In the west central another ridge passes through the townships of Clay, Gregg, East Jefferson and South Monroe.

Road improvement in parts of the county is a difficult problem, not only from the standpoint of road material, but also of surface topography. In some townships the region is so rough that it is impossible to gravel or stone the roads on account of steep hills. Although most of the townships have an abundant supply of gravel, but few miles in the county have been graveled.

Newman Pit.—Northeast quarter section 6 (14 N., 2 E.). This deposit is located in the second terrace of White River. It is of river deposition. Several acres are underlain with gravel, which is of a light gray color, rather coarse and free from clay and dirt. It contains some limestone, and packs well when placed on the road. The gravel is sold at the rate of 10 cents per yard to the county and township. Most of it is used in the township. This pit was opened 25 years ago, and roads built from it are yet in good shape.

E. Lane Pit.—Southwest quarter section 18 (14 N., 2 E.). This deposit is located in the morainic ridge bordering the river. The gravel from it is not used, as it is too sandy. The deposit is an extremely large one, but not of good quality.

Wayne Township.

Wayne Township is well supplied with gravel in the eastern and central portions, but little gravel is to be had in the western part. Gravel is obtained from the bed of Eagle Creek and White River. In the northeast part of the township pit gravel is plentiful.

J. J. Cooper Pit.—Northwest quarter section 21 (16 N., 3 E.). There is a ridge extending through sections 21 and 28, along White River, which is underlain with gravel. This deposit is extremely large, several acres being underlain with gravel.

Section of Cooper Pit.

	Feet.	Inches.
1. Clay soil	2 to 4	......
2. Sand and gravel, reddish brown	......	6 to 10
3. Stratified gravel and sand	14 to 16	......

The gravel occurs in lenses, no seams being continuous, the gravel merging into sand, and the sand into gravel. Often pockets of fine sand occur. Where the gravel can be gotten, free from sand, it is of excellent quality, being light bluish gray in color, largely quartz, with some limestone.

MORGAN COUNTY.

Area in square miles	415
Population in 1900	20,457
Miles of public roads	500
Miles of roads improved	140
Percentage of roads improved	28
Miles improved with gravel	100
Miles improved with crushed stone	40
Average original cost of gravel roads per mile	$900
Average original cost of stone roads per mile	$1,700
Total original cost of improved roads	$158,000
Annual cost of repairs per mile on gravel roads 5 years old	$50
Annual cost of repairs per mile on stone roads 5 years old	$50
Miles of improved road (gravel) built in 1905	17
Miles of improved road (stone) built in 1905	12
Miles of improved road (gravel) contracted for 1906	14
Miles of improved road (stone) contracted for 1906	5
First improved roads built	1860
Proportion of roads improved since 1895 (per cent.)	50
Satisfaction of farmers with investment in improved roads	Good
Authority	B. R. Johnson, County Auditor

Morgan County is level in the northwestern part, while in the central, southern and southwestern portions it is hilly and broken. In the northern part, we find the later drift exceedingly thick, while in the central and southern portions we have the hills covered but thinly with the earlier or Illinoian drift.

The central part of the county is traversed by the valley of the White River, which at its widest point in the county reaches a width of two miles. This valley is bounded on both sides by high hills, some reaching an elevation of over 100 feet.

Morainic ridges are prominent. In the southeastern, a ridge extends from Martinsville, the county seat, in a southeast direction to Morgantown. In the northeast a ridge is prominent through Harrison, southern Madison and northwestern Green townships. In the west central another ridge passes through the townships of Clay, Gregg, East Jefferson and South Monroe.

Road improvement in parts of the county is a difficult problem, not only from the standpoint of road material, but also of surface topography. In some townships the region is so rough that it is impossible to gravel or stone the roads on account of steep hills. Although most of the townships have an abundant supply of gravel, but few miles in the county have been graveled.

Road Materials of Morgan County.

The townships having a good supply of gravel are: Harrison, Clay, North Washington, Ray, Green, Madison and Brown. Those having a small supply are Gregg, Monroe and Jackson, while those almost devoid of gravel are Adams, Ashland, Ray and South Washington.

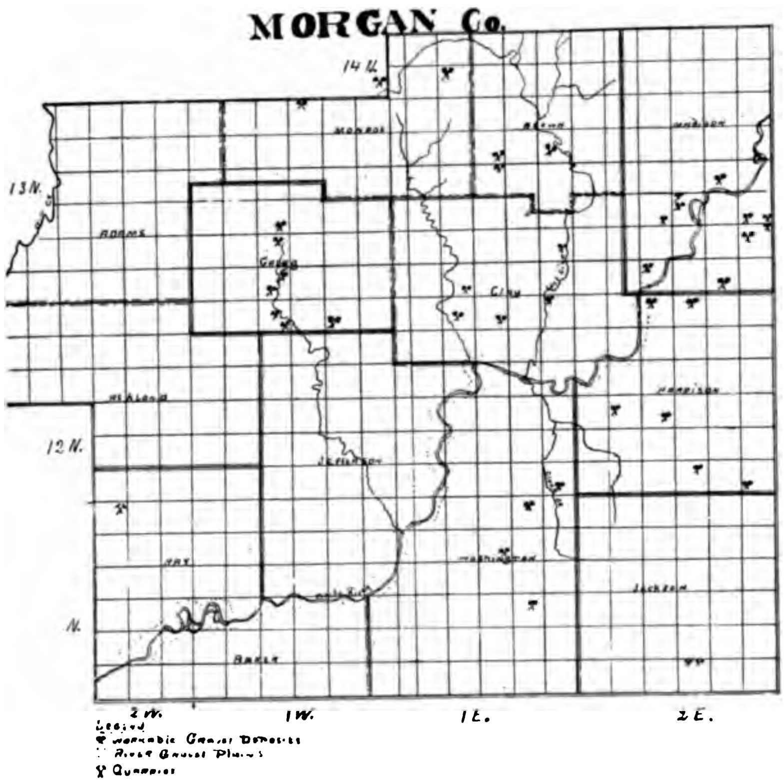

Fig. 45. Illustrating the distribution of road materials in Morgan County.

Gravel occurs in the morainic ridges above mentioned in Harrison, Madison, Green and Washington, in large deposits, while in the broad valley of the White River gravel may be obtained anywhere by dipping. In the southern part of the county, where the drift is not too deep, the Mitchell limestone or the knobstone shale outcrop on every hill. Every stream finds its bed on the shale.

In Ray and Ashland townships the Mississippian limestones (Mitchell, Harrodsburg and Bedford limestone) outcrop in a quarry, which is now being operated for rock metal. This is the only part of the county in which the limestone occurs near the surface.

Adams Township.

This township has no pit gravel, as it is level, at one time being a lake. Some attempt has been made to dip gravel, but the drift is too deep, and the gravel, where found, is too sandy to be of any value. Some gravel has been pumped in the southeast quarter section 24, but the gravel was mostly sand.

Monroe Township.

There is little gravel in the western part of this township, but some in the eastern part.

S. Hubbard Pit.—Northwest quarter section 33 (14 N., 1 E.).

	Feet.	Inches.
1. Clayey loam	4 to 5	..
2. Reddish clayey gravel	....	8
3. Gravel and sand	12	..
4. Clay.		

Width of hill	100 feet
Length of hill	180 feet
Depth of gravel	12 feet

Estimated 7,000 cubic yards.

This gravel is not of good quality. There is too much sand and clay present. The upper portion of the gravel is oxidized and is of a reddish color, while the lower is of a grayish color. The gravel is rather fine; there are coarse seams in different parts of the pit. Roads built of this are often repaired, as the traffic of vehicles soon cuts through the gravel.

O. A. Kennedy.—Northwest quarter of section 3 (13 N., 1 W.). Here is a small deposit located under Mr. Kennedy's barn. The deposit would not aggregate more than 3,000 cubic yards.

Ashland Township.

This township has no gravel, but has eleven and one-half miles of stone road and a contract let for eleven and a half miles more. The stone comes from Owen County.

Ray Township.

The southern part of Ray Township has plenty of gravel, as it borders on White River. The western part has no gravel. Limestone outcrops at several places, and is quarried on the land of ——— Martin, in the northeast quarter of section 3 (11 N., 2 W.).

Section of Martin's Quarry.

		Feet.
1.	Clay and soil stripping	4 to 5
2.	Fine grained limestone much weathered and broken highly colored by iron oxide	3
3.	Hard, bluish gray, compact, fine grained, nonfossiliferous limestone	4
4.	Compact, finely crystalline, bluish gray limestone, slightly fossiliferous with distinct bedding plains	4
5.	Finely crystalline, bluish, nonfossiliferous, compact limestone	6
6.	Dense, dark blue, finely crystalline, highly fossiliferous limestone	5

The formations are the Mitchell and the Harrodsburg of the Mississippian period.

The stone from this quarry has been placed on the road from Lewisville, in Ashland Township, to Paragon, Ray Township. About eight miles of road have been improved from it.

The crusher is owned by Mr. Martin, who took the contract for the making of 22 miles of road for the county. It is of the Gates type, a small one, capable of turning out 150 cubic yards per day. Twelve men are employed at the quarry and six or seven to haul the rock to the road. The rock is crushed and placed on the road at the rate of $1.00 per yard.

As no test was made of the stone its value for road material could only be estimated by examining the road where it has been used nearly a year. This road showed the stone to be of excellent quality. It packs well, has a good cementing value, and makes a smooth, even track.

Jefferson Township.

This township is exceedingly rough, a prominent ridge covering almost its entire area. Only the county roads are graveled. The eastern part of the township can get sufficient gravel from the White River valley. The hills bordering White River are thinly covered with drift, the knobstone shale outcropping in nearly every hill.

Gregg Township.

Gregg Township is very rough, so that but few of the roads have been graveled.

The S. Miller Pit.—Southwest quarter section 33 (13 N., 1 W.). The gravel outcrops here along the bluffs bordering Burnett's Creek. It is a river deposit, comprising almost 7,000 cubic yards.

Section of Miller Pit.

	Feet.	Inches.
1. Clay stripping	2 to 4	....
2. Gravelly clay with iron oxide	....	8 to 10
3. Gravel and sand stratified, sand layers 1 to 2 inches thick	14	....
4. Shale.		

The upper four to six feet of gravel in No. 3 are coarser than those below.

This is the best deposit in Gregg Township. The gravel is free from dirt, but contains numerous large boulders of granite and limestone. The color of the upper eight or ten inches is reddish brown, while the lower portion is of a light gray. The pebbles are largely quartz, there being a small percentage of limestone and little shale, chert and sandstone.

This gravel makes a good roadbed, packing well and wearing evenly. Roads were examined upon which it had been used for three years and were found to be in good condition. The owner has stripped the pit and kept it in good condition, charging the township 15 cents per yard. The gravel is easily gotten at, and can be worked with little cost.

H. Brewer Pit.—Northwest quarter section 27 (13 N., 1 W.). This pit has been very nearly exhausted, there being not more than 3,000 or 4,000 yards left. More might be obtained if it could be dipped.

William Martin's Deposit.—Northeast quarter section 33 (13 N., 1 W.). This deposit has not been opened. The gravel is located in a bank bordering a branch of Barnett's Creek. It was impossible to estimate the amount of gravel here, as it is covered with a deep mantle of clay. It would be difficult to strip this deposit, as 6 to 10 feet of clay must be removed.

James Wilheit Pit.—Southeast quarter of southwest quarter section 4 (12 N., 1 W.). This is not a large deposit and occurs

in a small knob-shaped hill along Barnett's Creek. There is not more than 4,000 yards available.

Section of Wilheit Pit.

		Feet.	Inches.
1.	Clay stripping	2 to 3	......
2.	Reddish brown gravelly sand	....	6 to 8
3.	Gravel, upper part reddish yellow, lower grayish...	8	......
4.	Sandstone.		

The gravel is not of the best quality, as it contains a great amount of sand and some clay. There is a large percentage of sandstone pebbles present. It does not cement well when placed upon the roads. The pit is located close to roads that need graveling, and about three-quarters of a mile has already been graveled from it. The pit is stripped by the owner and the gravel is sold to the township at the rate of 15 cents per yard.

Joseph Bryant Pit.—Southeast quarter section 4 (12 N., 1 W.). This also is but a small deposit, located on the top of a hill bordering Barnett Creek. The gravel is not of good quality, there being too much clay, sand and sandstone pebbles in it. There is not more than 5,000 yards at most. The same may be said of the Nicholson pit, which is located in east half of northwest quarter section 4.

There are also small deposits in Brewer's and Hicks's pits, section 27, but difficult to get at on account of heavy stripping.

Madison Township.

The Albert Haymaker Pit.—Northwest quarter section 22 (13 N., 2 E.).

Section.

		Feet.
1.	Stripping of clay	6 to 8
2.	Fine sand and gravel	5
3.	Gravel stratified, not coarse	3 to 4
4.	Sand with little clay	1
5.	Coarse gravel, free from sand and clay	5
6.	Fine gravel playing out on one edge into sand	3
7.	Gravel and sand	7
8.	Coarse gravel	10

This is a large deposit, in a bluff bordering a tributary to White River.

Length of hill	200 feet
Width of hill	150 feet
Depth of gravel	40 feet

A well, dug at the level of the bottom of the pit some distance from the bluff, was 30 feet in depth and all the way in gravel and sand. This is one of the best deposits in the township. The gravel is of a light gray color, is of all degrees of coarseness, and contains few friable pebbles, the largest percentage of the pebbles being quartz, diabase and chert. The limestone pebbles are quite numerous. This gravel makes excellent roads. Some were examined upon which the gravel had been in use for several years.

The pit has been opened for 25 or 30 years, but gravel has not been taken out every year. In 1905 about 1,000 yards were hauled on the township and county roads. Some has been hauled into Clay Township. It is now mostly used for repair work. The pit is located right on the main traveled road, and is easily gotten at. The stripping is not expensive, so that the gravel is sold at the rate of 5 cents per yard.

Walter Hays Pit.—North half of northwest quarter section 22 (13 N., 2 E.). This pit is located about one-half mile back of the Haymaker pit. It is in a roundish hill about 40 or 50 feet high. It is of glacial origin, the hill being a kame. The pit is circular, having a diameter of 200 feet. The deposit contains 10,000 to 12,000 cubic yards.

Section of Hays Pit.

	Feet.	Inches.
1. Clay soil stripping	..	18
2. Fine loamy sand	..	8
3. Coarse gravel, around pit, with stones averaging 2 inches in diameter	1	..
4. Layer of fine stratified gravel. Thins out in places and thickens in others. Cross-bedded	4	..
5. Coarse stratified gravel and sand running in lenses	12	..

The Mooresville and Waverly pike, a county road, was graveled from this pit 14 years ago, and has only had to be regraveled in patches, and these were where washouts had removed the gravel. The latter cements well when placed on the roads, making a hard, smooth roadbed.

The pit is located one-half mile from a main traveled road, is easily stripped and worked without interference of ground water. The gravel is sold to the township and county for 5 cents per load.

James Thacker Pit.—Southeast quarter section 14 (13 N., 2 E.). This deposit occurs in the second river terrace on the old flood plain of White River and is of river deposition. It is a large deposit, 5 or 6 acres being underlain with a vein of gravel 12 to 14 feet thick.

Section of Thacker Pit.

	Feet.	Inches.
1. Loamy soil stripping	..	6 to 12
2. Coarse gravel, pebbles averaging 2 to 3 inches in diameter	..	8
3. Finer gravel, pebbles averaging 1 to 1½ inches in diameter	3	......
4. Layers of fine and coarse alternating with thin layers of sand	12	......

The quality of this gravel is equal to that of the Haymaker pit. It is clean, free from soft pebbles, cements well, making solid roads, is of a grayish color and of good size. Roads built of this gravel 8 or 10 years ago are yet in good condition. The cost to county and township is 10 cents per yard. Little of the gravel is used now except for repair work.

Milt Thornburg Deposit.—South half of southeast quarter section 21 and northeast quarter of section 28 (13 N., 2 E.). Here is a large deposit of gravel, but of poor quality, as there is too much clay and dirt mixed with it. But little of this gravel has been placed upon the roads.

Brown Township.

Brown Township is well supplied with both pit and bar gravel. White Lick Creek flows through the northwestern part of the township, and through the eastern, a branch of White Lick, both of which contain good bar gravel.

Newby Pit.—Southwest quarter section 12 (13 N., 1 E.). This pit is no longer used, as the gravel is too sandy. The deposit is quite a large one, but of little value. It would do for repair in case of necessity. By screening much good gravel could be obtained.

Devers and Fletcher Deposits.—West half of northwest quarter section 14 and southwest quarter of southwest quarter section 11 (13 N., 1 E.). Neither of these deposits has been opened. They occur in a prominent ridge, bordering a branch of East Lick Creek, and are of glacial origin, being kames.

Length of ridge	1,000 feet
Width of ridge	75 feet
Height of ridge	50 feet

A well sunk close to the hill passes through 30 feet of gravel. These deposits are located right on the public road and close to unimproved roads.

Everett Allen Deposit.—Northeast quarter section 2 (13 N., 1 E.). An extensive gravel deposit is located on Mr. Allen's farm, just outside Mooresville. It is located in the high river terrace bordering East Lick Creek, which runs in an east and west direction south of the town. The deposit has not been opened, but could be utilized with little expense. Gravel also occurs on William Morris's farm, northwest quarter section 1. The outcrop may be seen at base of hill, along the side of the road.

Harrison Township.

Harrison Township is supplied with a large amount of excellent gravel, the deposits so located as to be within short distances of unimproved roads. They all occur in the morainic ridge and are of glacial origin, a large number of them being kames.

Scott Kelley Pit.—Southwest quarter section 25 (13 N., 2 E.).

Mr. Kelley has an excellent deposit of gravel which is just being opened up. It occurs in a ridge-like hill bordering a branch of White River.

Length of hill	400 feet
Width of hill	100 feet
Depth of gravel	20 feet

The gravel is of a light gray color, free from sandstone and clay, contains a little sand, grades from coarse to fine in different parts of the deposit, is largely of quartz pebbles, and cements well when placed on the road. The pit is back off the road about

one-half mile, but is easily available. Little stripping is necessary, as the gravel comes close to the surface.

George Brenton Deposit.—Southwest quarter section 24 (13 N., 2 E.). Mr. Brenton's deposit is located in a ridge-like hill bordering a small tributary of White River. It is a large one and could easily be opened up, as very little stripping is necessary. The gravel is of good quality and close to a section road. The deposit would easily supply 15,000 to 20,000 cubic yards of gravel.

T. S. Underwood Pit.—Southwest quarter section 26 (13 N., 2 E.). This is undoubtedly the largest and best deposit of gravel in Harrison Township.

Length of hill	500 feet
Width of hill	240 feet
Height of hill	30 feet

Section of Underwood Pit.

		Feet.	Inches.
1.	Clay and soil stripping	..	6 to 12
2.	Gravel and fine sand	..	6
3.	Stratified gravel and sand, well cross-bedded	10	....
4.	Coarse stratified sand and gravel, cross-bedded, with lenses of sand alternating with lenses of gravel	20	....
5.	Bottom of gravel not reached.		

The gravel is almost free from dirt and clay, and little stripping is required. Sand occurs, but not in sufficient quantity to destroy the value of the gravel. The color varies. At the top it is of a reddish color, while below it is of a light gray. The oxidized portion is but slight. The pebbles average one-half to one inch in diameter. There are seams of finer gravel, which often merge into lenses of sand. The pebbles are largely quartz, with some limestone, and a small percentage each of sandstone, diorite, diabase and chert. The cementing principle is mostly lime. The pebbles are tough and withstand the abrasion of vehicles.

This deposit has been opened two years. In 1904, 200 yards were hauled onto the township roads. About one and one-half miles of road have been graveled from the pit. It is used now largely for concrete work and road bridges. The pit needs little stripping to keep it open, so that the owner, to encourage road improvement, sells the gravel at 5 cents per load.

John Paul Pit.—Northwest quarter of northeast quarter section 35 (13 N., 2 E.). This pit has been opened for about 25 years. A large amount of gravel has been hauled from it into Johnson County. Last year 300 yards were hauled into that county. The pit still contains enough gravel to gravel several miles of road. The gravel costs the township 6 to 8 cents per yard.

Green Township.

Green Township is well supplied with gravel. The deposits are large and of good quality. They are well distributed throughout the township, so that long hauls are not necessary. In spite of this fact the township has few miles of improved roads. The deposits are associated with the terminal moraine and are mostly kames.

J. W. Musser.—Northeast quarter section 3 (12 N., 2 E.). This deposit occurs in a long ridge-like hill, a kame, and is of glacial origin.

Length of hill	360 feet
Width of hill	120 feet
Depth of gravel	45 feet

Section of Musser Pit.

		Feet.	Inches.
1.	Clayey soil	..	2 to 6
2.	Yellowish brown, oxidized gravel	..	10
3.	Gravel, with pockets of sand, both highly cross-bedded	40	......

In places gravel outcrops on top of the hill. The main hill of gravel is free from dirt, but contains numerous sandstone pebbles. The color is of a light gray below and yellowish brown above, where oxidation has taken place. The pebbles average one-half inch in diameter. Some parts of the deposit are fine, while others are coarser. The pebbles are largely quartz, diabase, dolorite, with some chert, limestone and sandstone. They are tough, resisting the wear of vehicles excellently.

A road was examined upon which the gravel had been placed two years ago. The pebbles show little wear. The gravel packs well, making a firm, compact roadbed. About two miles of road have been improved from this pit. All of the gravel from this

pit has been used in the township. The price paid for it is 5 cents per load.

The pit is back off the road some distance and is difficult to get to, so that hauling to the place needed is the most expensive part. Little stripping is necessary, as gravel comes to the surface and can be loaded into wagons without interference of water.

Dr. Horton's Pit.—Northeast quarter section 4 (12 N., 2 E.). This deposit occurs in a rounded-like hill, a kame, in structure.

Length of hill	300 feet
Width of hill	75 feet
Depth of gravel	......

Section of Horton Pit.

	Feet.	Inches.
1. Clayey soil stripping	......	6 to 8
2. Fine gravel and sand	......	8 to 10
3. Coarse, stratified gravel	1	....
4. Gravel with thin layers of sand. The layers of sand varying in thickness, averaging one-half to one inch	20 to 30	....

The depth of gravel was not determined. A well sunk at the foot of the hill penetrated sand and gravel for 20 feet. The gravel is of a bluish gray color, is free from clay and dirt, and the pebbles of good size, the average diameter being one-fourth to one-half inch. The quartz, diorite and diabase pebbles abound, with a small percentage of chert, limestone and sandstone present.

Roads made of this gravel three years ago are in excellent condition, the gravel showing little wear, packing well, and making a smooth, compact bed. The pit is located right on the public highway, and needs little stripping, so that gravel is sold to the county at the small price of 5 cents per load.

Thomas Adams Pit.—East half of southeast quarter section 19 (12 N., 2 E.). This pit is located along Clear Creek, and is a prominent ridge, standing about 40 feet above the level flat along the river. The ridge is a kame, of glacial origin.

Length of ridge	600 feet
Width of ridge	150 feet
Depth of gravel	40 feet

Section of Adams Pit.

		Feet.	Inches.
1.	Clayey loam	....	6 to 12
2.	Clay and gravel	....	8 to 10
3.	Fine, stratified gravel and sand	1 to 3	....
4.	Coarse, stratified gravel with little sand	1 to 2	....
5.	Stratified sand and gravel, with layers of sand ranging from one-half inch to three inches in thickness	30	....

The gravel is highly cross-bedded, no layer being continuous across the pit. The sand occurs in lenses, while large masses of gravel have become cemented together by lime carbonate. The gravel is of a light gray color throughout, with little dirt or clay. The pebbles average one-half inch in diameter. Those of quartz, diabase and diorite predominate, with a good percentage of limestone and chert.

The gravel is of good quality, resisting to a marked degree the wear and tear of traffic. It packs well, the limestone furnishing the cementing material. It is sold to the county and township at the rate of 9 cents per yard. The pit is located close to a main traveled road, so that its availability is of the best.

William Adams Pit.—Northeast quarter section 21 (12 N., 2 E.). This pit is of about the same size as the Thomas Adams pit and of the same quality.

Jacob Dressler Pit.—Northeast quarter of northeast quarter section 33 (12 N., 2 E.). This deposit is of glacial origin, occurring in a kame-like hill.

Length of hill	320 feet
Width of hill	150 feet
Depth of gravel	30 feet

Section of Dressler Pit.

		Feet.	Inches.
1.	Clayey soil (on top) (On sides deeper.)	..	4 to 6
2.	A reddish clayey gravel (oxidized)	..	8
3.	Coarse gravel	2	......
4.	Stratified sand and gravel	20	......

The upper surface of the gravel is oxidized, being a reddish brown color, while below it is a light gray. Throughout the de-

posit masses of clay and sand occur. In portions of the pit the gravel has been cemented together. It is of medium coarseness, with a large percentage of limestone pebbles. These pebbles are surrounded with a thin coating of clay, which together with the lime, cause them to cement closely together when placed on the road. A roadbed was examined where this gravel had been in use for two years and was found to be as good as the day placed on. The gravel packs well, making a smooth, hard roadbed. The pebbles wear evenly, so that few rut holes were found in the road.

This pit is located close to a main traveled road, so that it is not difficult to get at. It is also close to unimproved roads. Little stripping is required and there is no water to interfere. About two miles of road have been graveled from this pit. The owner strips the pit and charges the county and township 9 cents per yard for the gravel.

Felix Easting Pit.—Southwest quarter of southwest quarter section 36 (12 N., 2 E.). This pit was opened during the last year, so that little gravel has been taken out. The pit is a large one, and the gravel of good quality. This should be a valuable deposit, as it is in a part of the township where gravel is not so plentiful.

Jackson Township.

This township has no gravel of any consequence. The township is very rolling, the hills being covered with a pebbless clay. Small, worthless deposits were located in section 34, on the farms of Telford Merriman and James Miller. Here the deposits are largely clay and sandstone.

Washington Township.

This township is well supplied with gravel, except in the southern part, where no gravel could be located. The country here is too rough for road improvement were the material present. Gravel may be obtained anywhere in the morainic belt that extends southeast of Martinsville, and also in the valley plain of the White River, which here reaches a width of two miles.

Big Four Pit.—Section 23 (11 N., 1 E.). This deposit is a large one, being a union of three kames. The hill is a long ridge

and stands about 60 feet above the surrounding plain of Indian Creek.

Length of hill	600 feet
Width of hill	200 feet
Height of gravel	60 feet

This pit is owned by the Big Four Railroad, the railroad buying up the land when the road was first built for the purpose of getting gravel for ballast. After some time the railway did not care for continued use of the gravel, as it was not coarse enough, so sold the land but retained 10 acres, on which the pit is located.

Section of Big Four Pit.

	Feet.	Inches.
1. A clayey loam	....	12 to 18
2. A reddish brown (oxidized) gravelly clay	1 to 2	....
3. Stratified gravel and sand, highly cross-bedded	50	....

No layer of gravel or sand is continuous across the pit, but a gravel layer merges into sand or into another layer of gravel with a different dip. Some layers are coarse, others fine.

The gravel is free from dirt, but contains some clay, and numerous sandstone pebbles. These pebbles often reach good sizes. The gravel is of a light gray color below. Different degrees of coarseness may be had. The lower portions are often cemented together into great masses. The road from Mahalasville to Martinsville, built from this pit 15 years ago, has only had to be regraveled in places. The pit has been opened for 25 years. A large amount of the gravel is used in Washington Township, but quite a quantity is also hauled into Jackson. The deposit is right on the main traveled road and close to unimproved roads. The railroad sells this gravel to the county and township at the rate of 10 cents per yard. A blower must be used to get the gravel down, as the face of the pit is about 60 feet in height.

John W. Hammond Pit.—Center of section 36 (11 N., 1 E.). This deposit occurs in a long ridge-like hill. The hill is of a glacial origin, and is associated with the morainic belt before mentioned.

Length of hill	600 feet
Width of hill	120 feet
Depth of deposit	30 feet

Section of Hammond Pit.

		Feet.	Inches.
1.	Clayey soil stripping	..	6 to 12
2.	Deep red sandy clay	..	8 to 12
3.	Gravel with pillars of clay and pockets of sand	30	....

In the east end of the pit prominent pillars of clay, highly oxidized, occur. With this clay is fine sand.

The gravel in places is free from impurities, but in others contains much clay, sand and dirt. The color of the upper two feet is deep red, while below a light gray color predominates. In the lower portion of the pit the gravel has been cemented together in huge masses. All grades of coarseness may be obtained. Quartz and diabase pebbles predominate, but a large percentage of limestone and sandstone pebbles are present.

The gravel packs well and wears evenly. A road was examined where this gravel had been in use for a period of 12 years, and was found to be yet in good condition.

The pit is right on the main traveled road, easily gotten at, and easily stripped and worked. The county and township pay the owner 5 cents per load for all gravel hauled.

Gravel Deposit in Southwest Quarter Section 20 (11 N., 1 E.). This deposit is owned by the county. The deposit is not a large one, and not of good quality. There are probably 5,000 yards available.

Kit Kamer Pit.—Southeast quarter of southeast quarter section 10 (11 N., 1 E.). This deposit occurs in the prominent ridge which extends southeast of Martinsville. It is a well defined kame.

Length of opened deposit	300 feet
Width of opened deposit	150 feet
Depth of opened deposit	40 feet

This gravel is of about the same quality as that of the Big Four pit, being found in the same ridge. Most of that hauled from this pit is used in Washington Township. It is sold to county and township for 5 cents per load.

Gravel may be located at numerous points in the ridge, which extends just to the southeast of Martinsville.

Clay Township.

The eastern part of Clay Township is well supplied with gravel, as it is located in the plain of White River. Gravel may be had any place in this valley plain, as all the wells show it very near the surface. The western part of the township has little gravel, and were it present it would be of little value, as the region is too rough for road improvement.

Bar gravel is plentiful along East Lick Creek at numerous points.

JOHNSON COUNTY.

Area in square miles	312
Population in 1900	20,223
Miles of public roads	620
Miles of improved roads	240
Percentage of roads improved	38.7
Miles improved with gravel	240
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,250
Total cost of improved roads	$300,000
Annual cost of repairs per mile on gravel roads 5 years old	$90
Miles of improved road (gravel) built in 1905	6
First improved roads built	1868
Proportion of improved roads built since 1895 (per cent.)	10
Satisfaction of farmers with investment in improved roads	Good
Authority	Oscar V. Nay, County Auditor

Johnson County is much more level than Morgan. It is essentially a plain, except in the northern part, where there is a prominent morainic ridge running in an east and west direction, through the townships of White River, Pleasant and Clay. In the central part there is another ridge entering the county in the northwestern part of Union Township, extending in a southeasterly direction, passing just south of Franklin, the county seat, then turning to the east through Franklin Township and passing out into Shelby County.

There are also short ridges in the southwestern part of the county, in the townships of Hensley and Nineveh, and in the southeastern part of the county, in Blue River and South Franklin townships.

The drift of the northern, central and southeastern portions is of the last ice invasion, while in the southwest the older Illinoian drift is present.

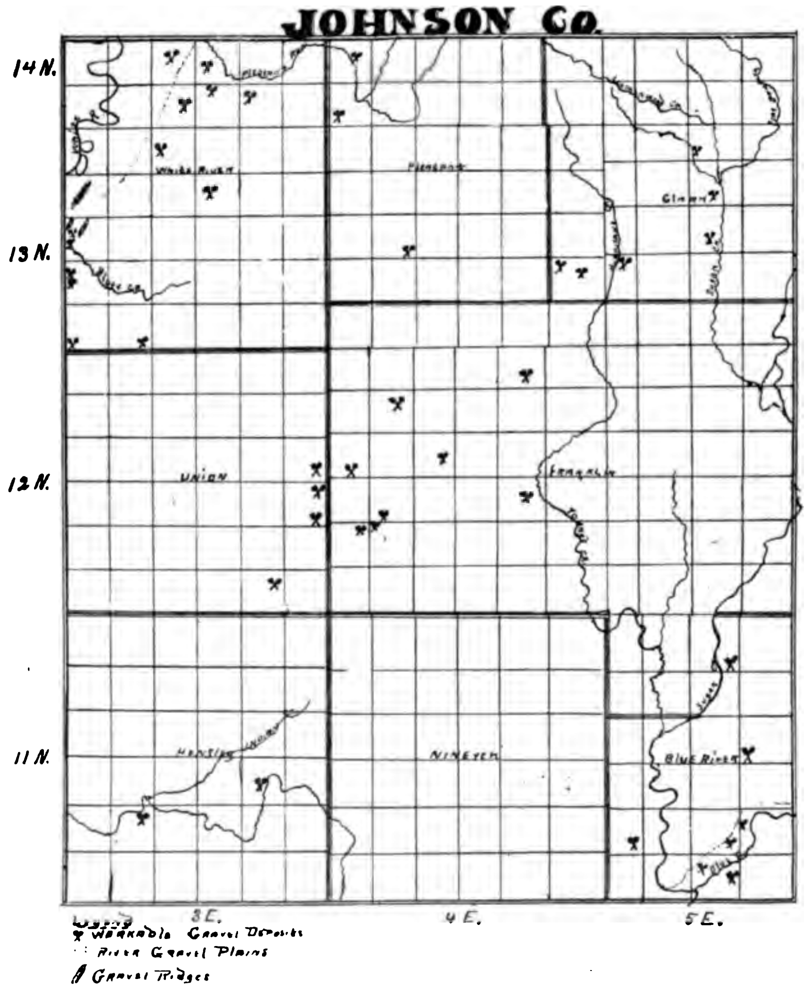

Fig. 46. Illustrating the distribution of road materials in Johnson County.

All of the main traveled roads have been graveled, but large amounts of gravel are needed for repair work, and new roads that are opening up. Johnson County has up to date 240 miles of fine graveled road. In 1904 the county spent $23,438.06 for road improvement.

Road Material of Johnson County.

Since the county is so deeply covered with drift, none of the streams have cut down to bed rock, nor have quarries been opened. The only material accessible in the county is therefore gravel.

The following townships are well supplied with gravel: White River, Blue River, Union, southwestern Franklin and eastern Clay. In all the other townships gravel is not plentiful. In the southeastern part of the county, bordering Blue River, are gravel plains which are probably the outwash from the morainic ridge in this vicinity. In Clark and Pleasant townships gravel must be dipped, as no pit gravel could be located. Gravel is plentiful along Sugar Creek, but must be dipped in many portions of the county. In White River large deposits occur associated with the morainic ridge.

Hensley Township.

Very little pit gravel could be located here. That for the roads has been taken from the bed of Indian Creek and other small tributaries. There are two pits of good size in the township.

Margaret Wolfington Pit.—Northeast quarter section 29 (11 N., 3 E.). This deposit is associated with the morainic ridge in southwestern Hensley. It is a long ridge-like hill, in the western end of which the gravel occurs.

Length of hill	250 feet
Width of hill	75 feet
Depth of gravel	16 feet

Section of Wolfington Pit.

		Inches.	Feet.
1.	Yellowish clay stripping	18 to	3
2.	Gravel and sand slightly oxidized	6 to 8	..
3.	Coarse gravel stratified	8	..
4.	Gravel and sand cross-bedded. Sand occurring in lenses	....	12
5.	Clay and shale at bottom.		

The gravel is of a reddish color at the surface, but quickly passes into a light gray color, when below the zone of oxidation. The deposit is free from dirt and clay. The gravel is largely quartz, with some limestone. No sandstone is present. All

grades of coarseness and fineness may be had. The gravel runs in lenses; in one part of the pit coarse, in another finer.

This deposit was opened in 1905. No gravel has yet been sold to the county for public roads. A large amount has been sold to the Indianapolis Southern Railway, which is passing through Morgantown, Morgan County. It is used in concrete work.

This gravel is of excellent quality and would make the best of road material. The pit is located off the main road one-quarter of a mile, but is easily available. Little stripping is required and the deposit is high enough so that water does not interfere. The railroad company is paying 15 cents per yard for concrete gravel.

R. T. Coffman Pit.—East half of southeast quarter section 23 (11 N., 3 E.). This deposit occurs in the bluffs bordering Indian Creek, and is of both glacial and river origin.

Length of deposit along bluffs	800-1,000 feet
Width of deposit along bluffs	100 feet
Depth of gravel	12 feet

The gravel is of a yellowish gray hue, the upper portion being highly oxidized. Deeper down the color is more of a bluish gray. The pebbles average one-half inch in diameter and are largely quartz, though some limestone, slate and sandstone are present. The deposit is free from clay and sand.

This gravel is all used in the township. The pit is now being opened to obtain gravel for the graveling of a new road about two miles south of the pit. About five miles of road have already been improved from this pit, as it has been opened for about 20 years. More or less gravel has been taken out every year. A road was examined where this gravel had been in use for a number of years and was found to be in excellent condition. The gravel packs like clay and wears evenly, thus making a smooth roadbed.

The gravel costs the county and township 15 to 20 cents per yard, and the county must strip it. The stripping is difficult, as the gravel is covered with several feet of clay.

Union Township.

Union Township has little gravel. The only locations of any importance were made in the eastern part.

Noel Boaz Pit.—Southwest quarter section 24 (12 N., 3 E.).

This deposit is located along a branch of South Fork Creek. It occurs in a long ridge-like hill, which is continuous with a large deposit of the old river plain.

There are twenty acres underlain with gravel. This deposit has been examined by the railway company and pronounced of good quality. There is some talk of the railway putting in a switch and getting gravel for their new roadbed.

Section of Boaz Pit.

	Feet.	Inches.
1. Loamy soil	2	..
2. Gravel slightly oxidized	..	6
3. Gravel and sand, stratified, cross-bedded	15	..
4. Bottom not reached.		

A well near the deposit penetrates gravel and sand for a distance of 30 feet. The gravel is free from dirt, is bluish gray in hue, and of different degrees of coarseness, probably averaging 1 inch in diameter. Patches of sand occur, but in such manner as not to affect the quality of the gravel. The pebbles are largely quartz and diabase with some limestone and chert.

The deposit is located within a few rods of the road and close to unimproved roads, is worked with little expense, since little stripping is necessary, and enough is above ground-water level, so as not to require dipping.

This deposit was opened in 1899 and since that time 6 miles of road have been graveled from it. The gravel does not pack well, but wears well. A road was examined where it had been in use for several years, and found to be in good condition.

Robert Vandine.—Northeast quarter section 30 (12 N., 4 E.). This is a small deposit, and of poor quality. The gravel is very clayey and dirty. There is an estimated amount of 5,000 yards that is still available.

Mollie Drenning Deposit.—East half of northeast quarter section 24 (12 N., 3 E.). This deposit has not been opened for public use. Some gravel has been taken out for private use.

Length of hill	200 feet
Width of hill	150 feet
Depth of gravel	12 feet

The gravel is only of fair quality, there being considerable clay and sand mixed with it.

William Garshwiler Pit.—West half of southwest quarter section 24 (12 N., 3 E.). This deposit occurs in a round knoll-like hill, and is of glacial origin.

Diameter of hill	100 feet
Depth of gravel	20 feet

Section of Garshwiler Pit.

		Feet.	Inches.
1.	Clayey soil stripping	2	..
2.	Reddish gravel and clay	..	8
3.	Gravel and sand, cross-bedded	12	..
4.	Blue till.		

The gravel is of a grayish color, is free from clay, but contains large portions of sand in certain portions of the pit. The pebbles are largely quartz, diabase, hornblendite, diorite and basalt. Their average size is one-half inch. The owner strips the pit and sells the gravel to the county and township for 20 cents per yard.

Blue River Township.

This township is well supplied with gravel, especially the southeastern part, where we have a well pronounced gravel plain along Blue River. This plain is probably the outwash from the morainic ridge to the north. All of the principal roads have been graveled.

Sam Brockman Deposit.—Southeast quarter section 4 (11 N., 5 E.). This deposit occurs along the bank of Sugar Creek and is terrace gravel. It is very shallow, but continuous for some distance along the stream. The upper portion is of a yellowish color, being oxidized. There are probably 5,000 cubic yards available.

James Hayes Pit.—West half of southwest quarter section 15 (11 N., 5 E.). Mr. Hayes's house is located on the ridge and also a schoolhouse. This deposit has not been opened, as there is a sufficiency of gravel without it.

Length of hill	300 feet
Width of hill	100 feet
Depth of gravel	15 feet

This will be difficult to work, as it is covered to a depth of 6

to 8 feet with clay. It is located at three corners, so that it would be easy to get to unimproved roads.

Deposit in Southwest Quarter Section 27.—Southwest of section 28 and northwest of section 33. This is part of the gravel plain bordering Blue River. Gravel may be obtained here by a removal of 2 to 6 feet of clay and soil. In the first mentioned section the interurban railway company has opened a pit and is hauling gravel on its line. The gravel is scooped up by steam shovel and loaded onto the car. It is rather coarse and of excellent quality.

Thomas Durbin Pit.—Southeast quarter section 30 (11 N., 5 E.). This deposit occurs in a long ridge-like hill. It is associated with the morainic ridge and is in origin a kame.

Length of area furnishing gravel...........	200 feet
Width of area furnishing gravel...........	75 feet
Depth of gravel.........................	15 feet

This gravel is not of good quality, as there is too much clay and sand present. It is too fine, and when placed on the road fails to pack well.

Nineveh Township.

But little gravel could be located in this township. In the northern part bar gravel is taken from Buckheart's Creek, and in the south from Nineveh Creek.

A small deposit was located in the southwest quarter of southeast quarter of section 28. The gravel is of little value, however, as it is too sandy.

Franklin Township.

Gravel is not plentiful in this township. Some pit gravel was located in the western part, but little in the central and eastern. The eastern part of the township obtains gravel from Sugar Creek, along which it is plentiful, both as bar and terrace gravel.

Samuel Beyers Pit.—Northwest quarter section 29 (12 N., 4 E.). This deposit is associated with the ridge drift which passes to the west of Franklin, and is a well worked kame.

Length of gravel hill.....................	300 feet
Width of gravel hill......................	75 feet
Depth of gravel.........................	16 feet

Section of Beyers Pit.

		Feet.	Inches.
1.	Clay and soil stripping	1 to 4	....
2.	Gravel and sand slightly oxidized	....	8 to 10
3.	Fine, stratified sand	....	4
4.	Gravel and sand, stratified and cross-bedded	12	....
5.	Blue till at bottom.		

In parts of the pit the gravel becomes quite sandy, the sand lenses often merging into gravel or the gravel into sand. The lower portion of the deposit is of a grayish color, while the upper is of a reddish yellow hue. Some clay is present in the gravel, but not in harmful amounts. The gravel varies in coarseness. The predominating pebbles are quartz, diabase, diorite, with some limestone and chert.

This pit has been open for a number of years. Gravel has been taken from it to improve the road from Franklin to Trafalgar. As most of the roads in the township are now improved, the gravel is used chiefly for repair work. The gravel does not pack well, as there is too much sand in it. The pit is stripped and kept in shape by the owner, who charges 15 cents per yard for the material.

Curtly Pit.—Northeast quarter section 8 (12 N., 4 E.). This deposit occurs in a very prominent hill, which has an elevation of about 60 feet above the surrounding country. The longer axis of the hill extends in a north and south direction. The deposit is of glacial origin and is a kame.

Length of hill with gravel	400 feet
Width of hill with gravel	200 feet
Depth of gravel	30 feet

Section of Curtly Pit.

		Feet.	Inches.
1.	Loamy sand stripping	..	6 to 12
2.	Fine sand	1	....
3.	Gravel with little sand	..	6
4.	Gravel with small lenses of sand	4	....
5.	Gravel, cross-bedded	..	16
6.	Sand interbedded with lenses of gravel	2	....
7.	Gravel and sand cross-bedded, pockets of sand numerous	18	....

The gravel is not coarse, averaging about one-half inch in diameter. There is too much sand for the quality to be of the best

for road purposes. There are lenses of excellent gravel and then portions of the pit where 50 per cent. is sand. The gravel is clean, of a grayish color and largely quartz. This gravel would be excellent for concrete work.

The gravel is mainly used in Franklin Township, though some has been hauled into Union Township. It is now used mostly for repair work. It fails to pack well, remaining loose on the roads, so that the wheels of vehicles cut through. The deposit is located on a main traveled road and central to an area needing gravel. The cost of stripping is very small, as little is required. The gravel is sold at the rate of 15 cents per yard.

James Eades Pit.—Southwest quarter section 18 (12 N., 4 E.). This deposit is a long ridge-like hill associated with the morainic belt. It is a kame, the gravel showing cross-bedding nicely.

Length of gravel-bearing ridge.............	400 feet
Width of gravel-bearing ridge.............	50 feet
Depth of gravel.........................	15 feet

There is another hill to the east of the opened pit, which has not been opened.

Section of Eades Pit.

		Feet.	Inches.
1.	Clayey soil stripping..............................	2 to 4	..
2.	Gravelly clay	....	8
3.	Oxidized gravel	1	..
4.	Gravel and sand—sand occurring in lenses..........	12	..

This gravel is of good quality, containing but a small per cent. of clay and dirt. The sand occurs in lens-like masses throughout the gravel. The gravel is coarse in places, the pebbles averaging one inch to one and one-half inches in diameter. Quartz, diabase and diorite predominate, with limestone and chert pebbles numerous.

The gravel is largely used in the township, being placed on both county and township roads. About two miles of road have been graveled from the pit, which has been opened two years. A road built two years ago of this gravel is in excellent condition. The gravel wears evenly, and packs well, carbonate of lime being the cementing principle. The owner strips the gravel, charging the county and township 20 cents per yard. The bottom of the gravel can not be reached, as probably 20 feet occur below ground-water level. To get it all it will be necessary to dip.

Clark Township.

Clark Township has little pit gravel. The only important locations that could be made are found in the gravel plain bordering Sugar Creek. Gravel may be obtained almost anywhere along this stream. It is being dipped along Hurricane Creek in the southwestern part of the township. There is no gravel in the northern part. A prominent boulder belt is here associated with the morainic ridge.

G. W. Hicks Deposit.—Northwest quarter section 16 (13 N., 5 E.). This deposit is located in the bottoms of Sugar Creek. There are several acres underlain with a vein of gravel 8 to 10 feet in thickness. This gravel could not be obtained without dipping, as the ground-water level comes very near the surface.

McClain's Pit.—Southeast quarter of southeast quarter section 8 (13 N., 5 E.). This deposit occurs on the old flood plain of Sugar Creek, and is of river origin. Several acres are underlain with a vein of gravel averaging from 6 to 8 feet in thickness.

Section of McClain Pit.

	Feet.	Inches.
1. Clay soil stripping................................	..	12 to 18
2. Brownish clayey gravel............................	..	12
3. Gravel and sand, of yellowish gray, stratified.......	10	....
4. Blue till at bottom.		

The coarseness of the gravel varies, in certain horizons being coarse, while in others it is finer. The coarsest pebbles will average 1 inch in diameter. Between the layers of gravel are thin layers of sand, ranging from one-half to one inch in thickness. The gravel above is oxidized, some iron oxide being present, while below it approaches a dark gray color. Quartz, diabase, diorite and basalts make up the largest percentage of pebbles, with limestone and chert next.

The pit is kept in good condition by the owner, who charges 15 cents per yard for gravel. The deposit is off the road one-fourth mile, but is easily available. This deposit and the preceding should be used, as they are close to roads needing improvement. This one can easily be worked, as it is higher than the one above referred to, so that water does not interfere.

J. L. Griffith.—Northwest quarter of northwest quarter section

30 (13 N., 5 E.). Gravel is here pumped from the bottom of a tributary of Sugar Creek and sold at 35 cents per yard. A good-sized deposit is also located on Mr. Hougham's farm, west half of northwest quarter section 25. This gravel must also be dipped.

Pleasant Township.

The only deposits of gravel located were found in the northwestern part of the township. No pit gravel could be located in the southern part. Some gravel is obtained from the beds of the streams. In the northwestern part of the township some gravel was located in association with the morainic ridge.

George McCarty Pit.—Southwest quarter section 31 (14 N., 4 E.). This deposit occurs in a large ridge-like hill back some distance from Pleasant Run. The hill is a kame.

Length of hill with gravel	175 feet
Width of hill with gravel	75 feet
Depth of gravel	15 feet

Section of McCarty Pit.

		Feet.
1.	Clay soil stripping	3 to 4
2.	Gravelly clay and sand	1
3.	Stratified sand, quite fine	4
4.	Gravel and sand, stratified and cross-bedded	6
5.	Gravel with large amount of sand	5
6.	Blue till at bottom.	

Parts of the pit contain good gravel, while others are altogether too fine for road purposes. The deposit, as a whole, is very sandy. The gravel is cross-bedded, so that a layer of sand often runs into a layer of sand. The color varies from reddish brown at the top to a light bluish gray at the bottom. The pebbles are largely quartz, diabase, basalts and diorites, with a large percentage of limestone, some of the limestone reaching a diameter of 6 to 8 inches. The gravel is free from dirt and sandstone.

This pit has been opened since 1900, gravel from it having been placed on both county and township roads. Some has been hauled into White River Township. Too much sand is present with the gravel to allow it to pack. Wheels cut through it easily. Where the gravel has been placed on the road free of the sand it packs well and wears evenly. The pit is stripped by the owner,

who charges the county and township 20 cents per yard for the gravel.

Arms Pit.—Northwest quarter section 30 (14 N., 4 E.). This deposit occurs along the banks of Pleasant Run. It is not a large deposit, the estimated amount still available being 5,000 cubic yards.

Section of Arms Pit.

	Feet.	Inches.
1. Clay stripping	5 to 6	..
2. Reddish brown gravel and clay	....	8
3. Oxidized gravel, of a reddish brown color	1	..
4. Stratified sand and gravel with now and then thin seams of clay	10	..

The gravel is of poor quality, as it contains too much clay, sand and dirt. A large number of sandstone pebbles are present.

White River Township.

This township contains enough good gravel to gravel all the roads in the county. Exceedingly large deposits occur in the northwestern and western part of the township. Gravel may be found in the bluffs along White River in sections 7 and 8 (13 N., 3 E.). On the river bottom we find a gravel plain, where gravel may be had with very little stripping. The dotted line on the map locates definitely this area. All of the large deposits are kames, associated with the morainic ridge which in this county reaches its highest elevation in White River Township. There is little gravel in the southeastern part of the township.

Chris Nolan Pit.—Southeast quarter section 18 (13 N., 3 E.). This pit is located just opposite the bridge across Bluff's Creek. It is a long ridge-like hill, with a northwest-southeast direction. The hill is of glacial origin, and the gravel the deposition of glacial waters.

Length of hill with gravel	300 feet
Width of hill with gravel	150 feet
Depth of gravel	15 feet

Section of Nolan Pit.

	Feet.	Inches.
1. Clayey soil, stripping	2 to 3	..
2. Reddish brown gravel and clay	....	8
3. Gravel and sand highly cross-bedded and stratified	15	..
4. Clay at bottom.		

This gravel is of good quality, there being little clay and dirt in it. The sand occurs in lenses, so that the gravel can be taken out by itself. The gravel is of a reddish color above, while below it is of a grayish hue. It is largely made up of quartz, diorite, diabase and schist, with limestone and chert. The pebbles average one-half to one inch in diameter.

This gravel is tough, the pebbles withstanding the traffic of vehicles excellently. A road was examined where the gravel had been in use for several years. It was found to be in good shape, the gravel well cemented and free from ruts. The pit is located right on the public highway, so that it may be easily obtained. The gravel is easily stripped and worked, since water does not interfere. The owner strips the pit and sells the gravel to the county and township at the rate of 15 cents per yard.

N. K. Mann Pit.—Northwest quarter section 18 (13 N., 3 E.). This deposit is located just north of the preceding and is a part of the same ridge. There are about 20 acres underlain with gravel here. A well passes through 30 feet of gravel.

Section of Mann Pit.

	Feet.	Inches.
1. Clayey soil stripping	..	8 to 10
2. Gravel and sand (the layers of sand varying in thickness from 1 to 2 inches)	15	......

This gravel is also of excellent quality. The color is of a light gray. The pebbles vary in size from the top of the pit down, so that gravel of varying degrees of coarseness may be obtained. The deposit is free from clay, dirt and sandstone. The gravel is largely quartz, diabase, diorite and limestone.

This pit has been opened for ten years, and more or less gravel has been taken out every year. A large amount is now being used for concrete work and cement. About two miles of road have been graveled from the pit. The gravel is all used in White River Township, on both county and township roads. A road was examined where the gravel had been on for a period of three years. The road has required no repairs, and is little the worse for wear. The material packs well and wears evenly. The gravel is used for roads, for cement and concrete work. For cement, the owner gets 25 cents per yard, and for road purposes 15 cents per yard.

Le Roy Templeton.—Northwest quarter section 18 (13 N., 3 E.). There is here a large deposit which has not been opened. It occurs in a long ridge-like hill, which extends the entire length of the section. This hill stands above the river plain about 60 feet. The gravel is of good quality, but has not been opened because there is a sufficiency of gravel in the township already opened.

William Smith Pit.—Northeast quarter section 33 (14 N., 3 E.).

Length of hill in which gravel is found......	600 feet
Width of hill in which gravel is found.......	75 feet
Depth of gravel........................	15 feet

Section of Smith Pit.

	Feet.	Inches.
1. Clayey stripping on sides...........................	..	10 to 18
2. Gravel and sand, occurring in lenses highly cross-bedded	15	....

A large amount of sand is present in the gravel. The latter is of a grayish color, is free from dirt and clay, and contains few soft pebbles. Quartz pebbles predominate. Most of the gravel used from this pit has been hauled on the township roads. The owner strips the deposit and charges 15 cents per yard for the gravel.

Grant Hardin Deposit.—Northwest quarter of northwest quarter section 35 (14 N., 3 E.). This deposit is located in a hill-like knoll and is of glacial origin. The deposit has been opened about two years. It is not of good quality, as there is too much sand present. It has been placed on the roads, but does not prove to be of good quality.

Edwards Pit.—North half of northwest quarter section 35 (14 N., 3 E.). This large deposit occurs in a prominent hill, associated with the morainic ridge. The major axis extends in a northwest-southeast direction. The ridge has an elevation of 50 or 60 feet above the level of the surrounding plain.

Length of gravel ridge....................	600 feet
Width of gravel ridge.....................	100 feet
Depth of gravel........................	30 feet

Section of Edwards Pit.

		Feet.	Inches.
1.	Gravel and clay stripping	..	6 to 8
2.	Brownish red gravel	..	6
3.	Coarse gravel, pebbles 2 inches in diameter	2	......
4.	Gravel and sand	6	......
5.	Gravel with thin seams of sand	25	......

This gravel is of excellent quality and probably as good as any in the township. Any grade of coarseness may be obtained. The pebbles average one inch to one and one-half inches in diameter. The gravel is clean and of a grayish color. Quartz, diorite, basalt and schists predominate, with limestone following. The cementing material is the lime. This deposit has been opened for 30 years. From it gravel has been hauled on the county and township roads. The new railway from Indianapolis is considering putting in a branch switch up to the pit, so that they may obtain gravel for their new road. This pit is well located for unimproved roads. The gravel is sold to the county and town at the rate of 15 cents per yard, the owner stripping the pit. Little stripping is required, as the gravel outcrops at the surface and wagons can go on the top of the ridge and scoop up the gravel. This gravel, where placed upon the road, packs well and resists the wear of traffic. Roads built of it several years ago are yet in good shape, repairing only having to be done where the material has been washed away because of poor grading of the road.

John Fulmer Pit.—Northwest quarter section 15 (13 N., 3 E.). This deposit occurs in a large dome-like hill, standing about 70 feet above the surrounding country to the north. It occurs on the northern side of the morainic ridge. This is by far the largest deposit in Johnson County. There is enough gravel in this deposit alone to gravel 70 miles of road.

Length of hill	300 feet
Width of hill	200 feet
Depth of gravel	70 feet

Section of Fulmer Pit.

		Feet.
1.	Clay stripping	2 to 3
2.	Clay and gravel oxidized	1
3.	Fine sand and gravel	2
4.	Gravel and sand with cross-bedding nicely shown	50

In the lower stratum sand occurs in lenses, and the gravel often occurs likewise. A layer of gravel is often followed by one of sand. Lower down in the pit the gravel has been cemented together by lime carbonate. This gravel is of excellent quality and ought to be used on roads. It is clean, free from dirt and clay, the sand not running through it, so that gravel may be obtained with little sand. The gravel is of all grades of coarseness. If fine is desired it may be had; if coarse, it is there in large quantities. There is also excellent material here for concrete work. The pebbles are largely quartz, diabase, diorite and limestone.

This material is tough, wears evenly and cements well, making a smooth, compact roadbed. A road made of gravel from this pit was examined and found to be in excellent condition, though built several years ago. Most of the gravel has been used in the township, though some of it has been hauled into Pleasant Township. Several miles of road have already been improved from this pit. This gravel is sold at the rate of 10 and 12½ cents per yard. The pit is well located, being on a public road, easily gotten to and worked with little difficulty.

O. H. Tressler Deposit.—East half of northeast quarter section 19 (13 N., 3 E.). This deposit is located in the southern border of the morainic ridge, and in origin is similar to the Fulmer deposit. It is also a large deposit and capable of affording enough gravel to build 20 miles of road. In quality it is equal to the Fulmer pit, and is of about the same nature.

Martha Wiley.—Southeast quarter section 31 (13 N., 3 E.). A small deposit occurs here, but the gravel is not good, as there is too much clay mixed with it. It would be difficult to strip the gravel, as it is covered deeply with clay.

Coda Dresslar.—East half of northeast quarter section 30 (13 N., 3 E.). This deposit occurs in a steep bluff along Crooked Creek. The deposit is a kame and the gravel is highly cross-bedded and stratified.

Length of hill	175 feet
Width of hill	120 feet
Depth of gravel	30 feet

Section of Dresslar Pit.

		Feet.	Inches.
1.	Clay stripping	4 to 5	......
2.	Oxidized clay and gravel	....	6 to 8
3.	Gravel, stratified	30	......

The gravel is well stratified and cross-bedded. This is one of the best deposits in the county. The gravel is of about even quality throughout, there being little sand present and no clay. Around each pebble there is a thin film of clay and lime, so that when placed on the road it packs quickly. The pebbles average one inch in diameter, are largely quartz, and are tough. The color is a drab gray.

This pit has been opened three years, and gravel has been taken out every year for road repair and concrete work. About one and a half miles have been graveled from it.

One-half mile was placed on the county roads and the rest on the township roads. The gravel will stand the traffic, because it packs well and is tough, wears evenly and not wearing more in one place than another. The deposit is located right on the main section road, is easily worked, since no water interferes, and well located with regard to unimproved roads. The owner strips the pit and receives 10 cents per yard for all gravel hauled.

SHELBY COUNTY.

Area in square miles	408
Population in 1900	26,491
Miles of public roads	600
Miles of improved roads	285
Percentage of roads improved	47.5
Miles improved with gravel	285
Miles improved with crushed stone	None
Average original cost of gravel roads per mile	$1,500
Total original cost of improved roads	$427,500
Annual cost of repairs per mile on gravel roads 5 years old	$100
Miles of improved roads (gravel) built in 1905	1
Satisfaction of farmers with investment in improved roads	Good
Authority	Thos. Hawkins, County Auditor

Shelby County is largely a rolling plain of a ground moraine, there being a difference in surface topography in the southwest, where we find a well marked morainic ridge with an elevation of 50 to 60 feet above the surrounding surface plain. This is part

of the ridge from Johnson County. Another rough topography is developed in the southeastern part of the county along Flat Rock River, which is also a morainic ridge. The eastern part of the county is essentially a plain surface, while in the western part we find several ridges, the most prominent occurring in western

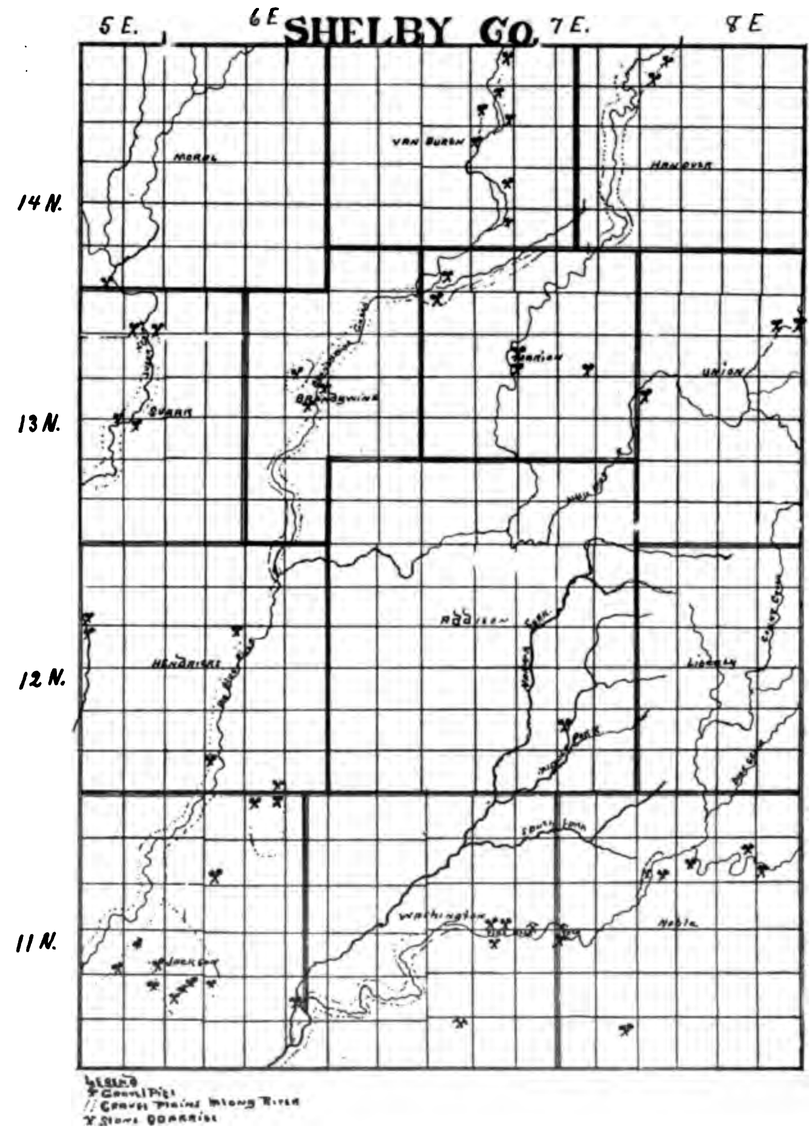

Fig. 47. Illustrating the distribution of road materials in Shelby County.

Moral, north Van Buren, west Hanover, east Brandywine and western Addison townships. The drift is all of the later ice invasion, and is thick in the western and shallower in the southern and southeastern parts of the county, where Flat Rock River cuts down to bed rock in several places.

Shelby County has 285 miles of graveled road, constructed at an average cost of $1,500 per mile. This rather high cost is due to the fact that the county is not well supplied with gravel in all parts, so that the cost of transportation and the gravel make the total cost per mile large. There are many miles of unimproved roads in the county.

Road Materials of Shelby County.

Shelby County has no stone suitable for roads. Limestone outcrops in East Washington and Noble Townships, but not of sufficient quantity for road purposes. The material at hand, then, for improvement is gravel. As this is not plentiful in all parts of the county, it must often be hauled long distances. This increases the cost.

The townships well supplied with gravel are as follows: Brandywine, Sugar, Hendricks, west Jackson and central Van Buren. Those having little gravel are: Southeast Addison, Union, Liberty, south Noble, Moral and west Van Buren. A large amount of the gravel used is obtained from the bed of streams. Bar gravel is plentiful along Big Blue River and Sugar Creek on the west, and Flat Rock River and Little Blue in the central portion. Very little pit gravel could be located.

A large gravel plain is found east of Fairland and north and west of Morristown. These gravel plains are probably outwash plains from the terminal moraine, or may be valley trains. Probably the nearest approach to an outwash plain is found in the extensive gravel plain to the east and north of Fairland. This plain slopes to the east into the drainage basin of the Brandywine. In the southwestern part of the county, in Jackson Township, the gravel is associated with the morainic ridge. Here are numerous kames, with abundance of gravel. Along the Big Blue gravel may be obtained by dipping.

It is located in the second terrace. The deposit is a large one. Several acres are underlain with good workable gravel.

Section of Bassett Pit.

		Feet.	Inches.
1.	Loamy soil stripping	1 to 2	....
2.	Reddish brown clay with gravel	....	10 to 12
3.	Fine gravel and sand	....	8 to 10
4.	Coarse gravel. Pebbles averaging 2 inches in diameter	2	....
5.	Layer of fine sand	....	2
6.	Gravel and sand	10	....

The bottom of the gravel can not be reached, as the groundwater level is struck at a depth of 10 feet. A rod was sunk several feet into the gravel and no bottom found.

This gravel is the best in the township. It is free from clay, contains little dirt and sand, and is of the right degree of coarseness for public roads. The color is of a grayish brown. A number of limestone pebbles are present.

This gravel is hauled six and seven miles. Not all is used in Hanover Township, but large amounts are hauled into Hancock County. It is placed on both the county and township roads. A road built about three years ago with gravel from this pit was examined. The gravel packs well, making an extremely smooth roadbed. It is sold to the county and township at the rate of 15 cents per yard. The pit is not well located, as it requires long hauls to unimproved roads.

C., H. & D. Railway Pit (John Foner).—Northwest quarter section 12 (14 N., 7 E.). The C., H. & D. Railway has an immense pit here, from which the gravel used for their roadbed is secured. A track has been built down into the pit, so that cars may be loaded from the banks. Several acres have been removed.

Tom Miller Pit.—Southwest quarter section 11 (14 N., 7 E.). This deposit occurs along the Blue River. It is mostly bar gravel. There is sufficient quantity to gravel several miles of road. The gravel is coarse and free from sand. It is sold to the township at the rate of 10 cents per yard.

Union Township.

Gravel in Union Township is very scarce. The only locations made were those along the Little Blue River. The gravel used upon the roads has been obtained from the bed of Blue River and other small streams.

A. Roades Pit.—Northwest quarter of southwest quarter section 13 (13 N., 7 E.). The deposit is located along the east bank of Blue River and is a river deposit. This is a large deposit; the dimensions of workable gravel are as follows:

Length of workable gravel................	400 feet
Width of workable gravel.................	250 feet
Depth of workable gravel.................	8 feet

Section of Roades Pit.

		Feet.	Inches.
1.	Sandy loam stripping..............................	..	8 to 12
2.	Brownish black clay and gravel.....................	..	12
3.	Stratified gravel with thin layers of sand...........	8	....
4.	Blue till.		

This is the best gravel deposit in the township. The gravel is free from clay and contains little sand. The color varies from reddish brown at the top to a reddish gray below. The pebbles average one-half inch in diameter, and are largely quartz, diabase, diorite, basalt and limestone.

A large amount of the gravel has been hauled into Marion Township, where, during the summer of 1905, about two miles of road were graveled. It is also used in Union Township, on both county and township roads. This deposit has been opened for public use about four years. The gravel is sold to the township and county at the rate of 15 cents per yard, the owner stripping the pit and keeping it in good workable condition. The deposit is located handily to unimproved roads, and is easily available, as it is situated right by a public highway. Little stripping is required, and all the gravel may be obtained without interference of ground water.

Warfield Deposit.—Southwest quarter section 4 (13 N., 8 E.). The gravel here is located in the bank of Blue River, in the sec-

ond terrace. The deposit is a large one, several acres being underlain.

Section of Warfield Pit.

	Feet.	Inches.
1. Loamy soil stripping	1	..
2. Oxidized sand and gravel	..	10
3. Gravel and sand	8	..
4. Blue till at bottom.		

The gravel is too sandy for road purposes, the layers of sand being quite thick and numerous. A large amount is placed upon the roads, because gravel is not plentiful. The color varies from a brownish red above to a yellowish gray below. The gravel is fine, the pebbles averaging one-fourth to one-half inch in diameter.

A large amount of the gravel is hauled into Rush County, as the pit is close to the county line. Some has been placed on the roads in the township and some is hauled into south Hanover Township. In 1904, $200 worth was hauled into Rush County. The pit has only been open a little over a year. The owner strips the pit and sells the gravel to the county and township at the rate of 20 cents per yard.

Jasper Hester.—Northeast quarter section 9 (13 N., 8 E.). On Mr. Hester's place is an old channel which contains several thousand yards of good river gravel. When high water occurs, the current passes through the channel and fills it with gravel, so that in this way it may be obtained in large quantities. The gravel is coarse and contains little sand. The price for county and township is 15 cents per yard.

Marion Township.

Gravel occurs along Blue River, which runs through the township and along Little Brandywine in the northwestern part. Along both of these streams is a gravel plain, extending out some distance from the river channel. In places about 1 foot to 2 feet of stripping covers the gravel.

S. Briliman.—Southwest quarter section 9 (13 N., 7 E.). This deposit occurs just west of the station of Marion, along Blue River. It is a part of the old natural levee of Blue River. The gravel extends along the river for some distance. There is a vein of

about 6 to 8 feet that can be worked without water interference. The bottom of the gravel can not be reached without dipping.

Section of Briliman Pit.

	Feet.	Inches.
1. Sand and soil stripping	..	8 to 10
2. Coarse, yellow gravel	..	12
3. Gravel and sand, colored somewhat	7	......

The upper portion of the gravel is very coarse, the pebbles averaging 1 to 2 inches in diameter, and of a brownish color, while below the gravel is finer and mixed with more sand, and of a yellowish gray color. There are numerous large pebbles of limestone present. Quartz, diabase and basalts predominate.

Southwest Quarter Section 31 (14 N., 7 E.). Here is located a gravel plain bordering Little Brandywine Creek, in which the gravel comes within a few inches of the surface. Wells along on the plain show the bottom to be underlain with sand and gravel. The bottoms in sections 32 and 33 along this same stream are underlain with gravel. Not all of this gravel could be obtained without dipping.

Shady Deposit.—Southeast quarter section 10 (13 N., 7 E.). A small deposit occurs here on Mr. Shady's farm. Enough gravel might be secured here to gravel two or three miles of road, but it would be difficult to obtain, as it is covered with a thick layer of clay.

Brandywine Township.

This township is well supplied with gravel. East of Fairland is what appears to be an outwash plain from the morainic ridge to the west. This plain extends down the valley of the Brandywine. Just north of Fairland, wells examined show a drift of blue till 15 to 20 feet in thickness, while to the south and east well data show no till, the wells all being sunk into the gravel. Gravel occurs along the Brandywine. At several points examinations were made, and a vein of gravel varying in thickness from 6 to 8 feet was found. At various points the river has cut back into its flood plain, revealing the gravel below.

Trotter Pit.—Northeast quarter of northeast quarter section 16 (13 N., 6 E.). This pit occurs on the gravel plain just south and east of Fairland. There are twenty acres underlain here with a

seam of gravel 30 to 40 feet deep. The interurban traction company has opened a large pit just opposite Mr. Trotter's, where thousands of yards have been taken out and hauled on the line between Indianapolis and Shelbyville.

Section of Trotter Pit.

	Feet.	Inches.
1. Clay and gravel stripping	3 to 4	..
2. Oxidized gravel and clay	....	8
3. Cross-bedded gravel and sand, with now and then pillars of clay	10	..
4. Water.		

The gravel is of all grades of coarseness. In sections of the pit coarse gravel may be had, while in others fine gravel is plentiful. The color ranges from a brownish red above to a gray below. Some clay and sand occur, but generally in pillars and lenses, so that gravel of good quality may be worked. The pit is stripped by the owner, who charges 15 cents per yard for gravel. Not all of the best gravel can be obtained, as ground water interferes. To get the best gravel dippers should be used.

Mitchell Ham Farm.—Northeast quarter section 15 (3 N., 6 E.). This deposit is a part of the gravel plain along the Brandywine, east of Fairland. Several acres are here underlain with gravel.

Sugar Creek Township.

Sugar Creek Township is well supplied with gravel in the western part, where it may be found underlying the river plain. Several wells examined here show that the old valley has been filled to a depth of 30 to 40 feet with gravel. No gravel of any value could be located outside of this plain.

J. H. Lee Pit.—Northwest quarter of northwest quarter section 24, and northeast quarter of northeast quarter section 23 (13 N., 5 E.). Here both bank and bar gravel may be obtained. Very little bank gravel is used, as bar gravel is plentiful. The latter is of excellent quality, being free from clay, with little sand, and is coarse. The pebbles average one to one and one-half inches in diameter.

J. Smith Deposit.—Northwest quarter section 25 (13 N., 5 E.). A large deposit occurs here on Mr. Smith's farm. As yet it has not been opened.

J. T. Means.—South half section 26 (13 N., 5 E.). A large deposit is found here in the gravel plain along Big Sugar Creek. A large amount of this gravel may be gotten out without dipping.

W. McFadden Deposit.—Southeast quarter section 1 (13 N., 5 E.). This pit is located on the bottom of Sugar Creek, and is a portion of the Sugar Creek gravel plain. Several acres are underlain with gravel.

Section of McFadden Pit.

	Feet.	Inches.
1. Black soil stripping	..	8 to 10
2. Brownish black clay and gravel	..	10
3. Gravel and sand, upper part of gravel coarse	5	....
4. Water.		

The gravel is of a yellowish gray color, being highly oxidized. The upper portion is coarse, while the lower is finer and sandy. Some clay is present with the gravel. The pebbles are largely quartz and diabase, with some limestone. A road was examined where some of the gravel had been used for repair work. It packs well, making a smooth surface. The gravel is sold to the county and township for 15 cents per yard.

Francis Milton.—Northwest quarter section 12 (13 N., 5 E.). The gravel here occurs in the river plain and is of river origin. It is but a continuation of the gravel plains found all along Sugar Creek. There are several acres underlain with gravel here. It is not possible to obtain all of it without dipping, as a good part of the vein is under ground water.

The gravel is of fair quality, is of a yellowish brown color, is only medium for coarseness, and in places sandy. The pebbles are largely quartz, hornblendite, diabase and basalts, with some limestone and chert. The gravel is sold to the township at the rate of 15 cents per yard. The gravel packs well, the cement being lime carbonate and some iron. A little film of clay surrounds many of the pebbles, making a matrix.

Noble Township.

Little gravel could be located in the southern part of Noble Township. Some was located in the northeastern part, where it was found associated with the morainic ridge. Gravel occurs in numerous places along Flat Rock River. In the east part of the township the bed of Flat Rock River is on the Niagara limestone.

Limestone outcrops along the river in the following sections: 12, 13, 7 and 8. It appears also in Washington township in the northwest quarter section 21, just where the public road crosses the Flat Rock River, and also in the southeast quarter of the southeast quarter of section 21, at base of hill.

Major's Pit.—Southwest quarter southwest quarter section 9 (11 N., 8 E.). This large deposit occurs in a high hill bordering Flat Rock River, and is a kame in the prominent morainic ridge in southeastern Noble.

Length of gravel-bearing ridge..............	600 feet
Width of gravel-bearing ridge..............	100 feet
Depth of gravel.........................	16 feet

Section of Major's Pit.

	Feet.	Inches.
1. Clayey loam stripping.............................	1 to 2	..
2. Fine loamy sand.................................	....	6
3. Stratified, cross-bedded gravel and sand.............	15	..
4. Blue clay at bottom.		

The gravel is of a grayish color, is free from clay and dirt, and is of a good grade of coarseness, the pebbles averaging one-half inch in diameter. They are largely quartz, limestone, diabase, hornblendite and basalts.

This deposit is located right on the public road and within a short distance of unimproved roads. The stripping is not a difficult matter, as the material can be dumped into the ravine close by. The deposit is located on the top of the hill, so that all the gravel may be gotten out without interference of ground water. The gravel is sold to the county and township at the rate of 5 cents and 10 cents per yard. The gravel cements well, lime carbonate being the cementing principle, making a smooth, hard roadbed. The pebbles are tough and wear evenly.

John's Deposit.—Northeast quarter section 8 (11 N., 8 E.). Here is a large deposit located in the edge of the morainic ridge, which borders Flat Rock River on either side. This deposit has never been opened, but is of large size and of equal quality with that of the Major pit.

J. Buxton Deposit.—Southeast half section 12 (11 N., 7 E.). Here the deposit occurs in the bluff bordering Flat Rock River. It would, however, be difficult to get at, since the river is wide at

this point. The deposit is not of good quality, as too many rocks are associated with it. About 50 per cent. of the pebbles are limestone, averaging three to five inches in diameter.

Deposit in Northeast Quarter Section 35 (11 N., 7 E.). A small deposit occurs here, but is covered with a heavy stripping of clay, so that it would be difficult to work.

Washington Township.

Little gravel could be located in Washington, outside of the valley plain of Flat Rock River. At numerous places along the river gravel may be obtained with little difficulty. The Niagara limestone outcrops in sections 21 and 31.

A. Trimble Pit.—Southeast quarter section 17 (11 N., 7 E.). This large fluvial deposit occurs in the wide river plain bordering Big Flat Rock Creek. Several acres are here underlain with a seam of gravel 8 to 10 feet deep.

Section of Trimble Pit.

	Feet.	Inches.
1. Fine loamy soil	..	8 to 10
2. Reddish brown gravel and clay, many large stones present	..	3
3. Stratified, cross-bedded gravel and sand............	8	....

The gravel in portions of the pit is very coarse, with little sand, while in other portions it is finer and more sand is present. In the upper portions of the pit it is of a yellowish gray color, while below it is more of a dark gray hue. A large number of limestone boulders occur in the upper portions of the deposit, while the lower is almost free from large pebbles. The pebbles will average one-half inch in diameter.

This gravel is hauled into the extreme northern part of Washington Township, a distance of six miles, and also into Noble Township. The pit has been opened for 20 to 30 years, but gravel has not been taken out every year. The owner strips the pit and sells the gravel at the rate of 13 cents per yard. It is mostly used for repair work. This gravel is of excellent quality, packing quickly and making a smooth, compact bed. The pebbles are largely quartz, diorite, diabase and limestone.

S. Boone Deposit.—South half section 17 (11 N., 7 E.). This

deposit has never been opened up, but is of excellent quality and of good size. Mr. Boone has eight or ten acres underlain with gravel.

J. W. Rosencranz Pit.—Northeast quarter section 21 (11 N., 7 E.). This deposit occurs in the second terrace bordering Flat Rock River on the west.

Length of terrace with good gravel.........	400 feet
Width of terrace with good gravel..........	200 feet
Depth of terrace with good gravel...........	12 feet

Section of Rosencranz Pit.

		Feet.	Inches.
1.	Sandy loam stripping..................................	..	8
2.	Brownish red clay with large stones....................	..	10
3.	Layer of cobble stones averaging 3 to 6 inches in diameter	3	..
4.	Gravel and sand stratified and cross-bedded............	6	..

This gravel contains too many large stones to be of the best for road purposes. The western end of the deposit is composed almost entirely of pebbles of diorite, granite and diabase, about 2 to 5 inches in diameter, all well rounded. A large number of limestones are also present.

Underneath the layer of coarse pebbles is a vein of about six feet of good gravel, but it is almost impossible to get this out without getting the coarse pebbles mixed with it. Little of this is being used on the road, as it is too coarse.

Jackson Township.

This township is well supplied with gravel, in almost all parts. In the southwestern part a terminal moraine ridge is prominent, in which gravel may be found at will. I have marked out on the map an area showing these deposits.

Gravel is plentiful along Big Blue River, the bottoms being underlain with it. To the east and north of Mt. Auburn, in sections 4 and 9, is a gravel plain, called "Flat Plain," over which the gravel reaches a depth of 15 to 20 feet.

R. Piles Pit.—Northwest quarter section 4 (11 N., 6 E.). The gravel occurs here in a large hill, which stands above the surrounding level about 40 feet. The deposit is a large one, but part of it is covered with a heavy clay stripping.

Section of Piles Pit.

		Feet.	Inches.
1.	Clay stripping	5 to 7	......
2.	Gravel and clay highly oxidized	......	3 to 4
3.	Gravel and sand, with more sand than gravel	10 to 12	......

This gravel is of poor quality, as it is too fine and contains large amounts of clay and sand. It will not make good roads.

Coffin Deposit.—Northeast quarter of section 4 (11 N., 6 E.). This deposit is part of the same hill in the above mentioned pit. The gravel is of about the same quality. It is too clayey and sandy for road purposes.

Wilson Cochran Pit.—Southeast quarter section 28 (11 N., 6 E.). Mr. Cochran's pit is located on the present flood plain of Lewis Creek, a branch of Flat Rock River. The gravel is a river deposit in origin. There are five acres here underlain with workable gravel.

Section of Cochran Pit.

		Feet.	Inches.
1.	Sandy loam stripping	....	10
2.	Reddish brown gravel and sand	....	8
3.	Gravel and sand, stratified	6 to 8	..
4.	Blue till at bottom.		

The gravel here is of good quality, being coarse enough for road work. The color grades from a reddish brown above to a yellowish gray below. The deposit is free from large pebbles, is clean, and composed largely of quartz, limestone, diabase, diorite and basalt pebbles. The pit is located right on the public road, is easily worked, since ground water does not interfere. The owner gets 5 cents per load for gravel.

Deposit in Northwest Quarter Section 27 and Northeast Quarter Section 28 (11 N., 6 E.). Here is a good-sized deposit occurring along the bank of Lewis Creek. This deposit has not been opened, but may easily be worked when necessary.

George Snapp Pit.—North half of southeast quarter section 30 (11 N., 6 E.). This is probably one of the largest deposits in Jackson Township. It occurs in a long ridge-like hill which flanks the eastern side of a prominent morainic ridge. The hill is of glacial origin and is probably a kame.

Length of hill	500 feet
Width of hill	175 feet
Depth of gravel	30 feet

Section of Snapp Pit.

		Feet.	Inches.
1.	Sand soil stripping	..	2 to 6
2.	Reddish brown sand and gravel	..	12 to 18
3.	Stratified gravel and sand, in places cemented together	25	....

This is one of the best deposits in Jackson Township. The gravel is of a light gray color below, is free from dirt and clay, and varies with regard to coarseness. The sand occurs in lenses, any one layer of sand not being continuous for any great distance. Layers of gravel often merge into lenses of sand. The gravel is free from soft stones, the quartzes, diabases, hornblendites and basalts predominating, while limestone pebbles are numerous. In the lower portions of the pit it has become cemented together in one solid mass.

This gravel is largely used in the township for road graveling. It is sold to the township at the rate of 10 cents per yard. A road was examined where this gravel had been on for two years. It had packed well, worn evenly, so that the road was in as good condition as when first built.

P. A. Winterowd Deposit.—Southeast quarter section 8 (11 N., 6 E.). The deposit here occurs in a roundish-like hill, a kame in the edge of the morainic ridge. There are two kames, one of which is opened, the other one not. The dimensions of the opened one are as follows:

Length of hill	250 feet
Width of hill	100 feet
Depth of gravel	15 feet

Section of Winterowd Pit.

		Feet.	Inches.
1.	Loamy sand stripping	..	10 to 16
2.	Fine gravelly sand	..	6 to 8
3.	Stratified sand and gravel, coarse at top and grading into finer below	15	....

The gravel is of a light gray color, is free from clay, and dirt, but contains a large amount of fine sand. This deposit has just been opened, so that little has as yet been placed upon the roads.

Hendricks Township.

There is little gravel in the western part of the township. Gravel for the roads is obtained from the gravel plains along Blue River, in the east, and Big Sugar Creek, in the west. Gravel is taken from the river in sections 32, 4, 11 and 14.

Addison Township.

Little pit gravel could be located in the township. In the western part gravel is obtained from Blue River, many of the streets in Shelbyville having been graveled with gravel taken from Blue River. In the southeastern part some gravel is obtained from the beds of Middle and North Fork Creeks. The western part of the township is underlain with gravel, but the gravel would be difficult to obtain, as it is covered with several feet of stripping, and even were it not for the stripping, ground water would interfere, so that it would have to be dipped.

SECTION XI.

THE ROADS AND ROAD MATERIALS OF SOUTH-EASTERN INDIANA.

EMBRACING THE COUNTIES OF DEARBORN, OHIO, SWITZERLAND, JEFFERSON, JENNINGS, RIPLEY,* DECATUR, BARTHOLOMEW, JACKSON, SCOTT, CLARK, FLOYD AND HARRISON.

BY ROBERT W. ELLIS.

In the preparation of this report it has been the intention of the writer to present the subject in a manner that will be helpful to those readers to whom good roads are of the utmost importance. While much of the information herein contained may not be entirely new to the citizens of certain localities, it is hoped that it may prove to be of considerable advantage to them in determining and in understanding the possibilities of their respective regions. To the general reader, also, this information, with the other accompanying reports, should give a fair idea of the possibilities of the State in respect to the making and the wear of roads. A brief and simple description of the geology of the region under consideration is given, in the belief that many readers will value such a statement of the larger facts connected with the origin, the nature and the occurrence of the rocks and gravel that are commonly observed by every one.

GEOLOGY OF SOUTHEASTERN INDIANA.

The counties treated of in this report are as follows: Dearborn, Ohio, Switzerland, Jefferson, Jennings, Decatur, Bartholomew, Jackson, Scott, Clark, Floyd and Harrison. Other counties embraced within this area or lying adjacent to it, have practically the same geological structure as those counties which they join. Ripley County, while not worked by the writer, is not distinct, geologically, from the counties that surround it, and, in a general

*Ripley County was worked and reported on by L. C. Ward.

SKETCH MAP OF INDIANA
SHOWING AREA TREATED OF IN THE REPORT
ON "ROADS AND ROAD MATERIALS OF
SOUTHEASTERN INDIANA".

BY R.W. ELLIS

Fig. 48.

way, a description of the surrounding counties is a description of the rocks within it.

The area embraces rocks of every age from the Ordovician to the upper part of the Lower Carboniferous or Mississippian.

These rocks consist of limestones, sandstones, shales and certain intercalated beds of non-indurated clay. The rocks lie in an almost horizontal position, but dip gently in a westerly direction. The lowest rocks crop out in the eastern part of Switzerland County; the uppermost rocks of the area lie in disconnected patches in the western part of Harrison County.

To understand the arrangement of the rocks one should know that they have originally been formed in the bed of the sea under greater or less depth from the surface of the water. The original condition of what is now solid rock was that of a level bed of clay, mud or sand. This applies only to the kinds of rocks found in the area under consideration; it does not include rocks of igneous origin, such as the numerous boulders which have been introduced from the far north.

Sandstones are beds of sand that have been cemented by calcareous or siliceous solutions percolating through them. If the cementing material is abundant the beds are firm; if the cementing material is little in amount the beds are loosely consolidated. Sandstones, moreover, are formed from material that has been carried to its position by waves or ocean currents, and that has been derived from other rocks in their disintegration.

Shales were originally beds of mud or clay lying beneath the sea in which they were deposited. The material of which they are composed was derived from some adjacent land area, as was also that of the sand beds.

Limestones have a different origin. They are formed from shells of sea organisms or are chemically derived from sea water, and do not depend for their formation upon material being brought in by movements of the sea. These shells are deposited in more or less abundance along with the material that is chemically precipitated from sea water. Naturally, the limestones were accumulated in waters more remote from land than were shales and sandstones. Sometimes conditions were favorable for a mingling of materials, and clayey limestones were formed, or calcareous sandstones. Ac-

cording to the prevalence of one or the other material, the rocks took on the form of clayey limestones, sandy limestones, argillaceous sandstone or calcareous sandstone.

In order that conditions might be favorable to the deposition of rock beds in their region, the area over which deposition was taking place must have been at a much lower level than the area is at present. After consolidation, and while deposition continued in the lower parts, the beds have been upheaved until the upper portion lay exposed in an even sloping plain, with the highest part in the neighborhood of Cincinnati. The surface sloped toward the west and the lower portions still lay beneath the sea. Thus the successive formations were laid down, each with its edge a little farther removed from the central uplift. The strata would then lie as a series of blankets, with their edges successively outcropping toward the east or center of uplift, the most recently completed formation having its outcropping edge farthest away from the central uplift, and so on.

At this stage of development of the rock beds little erosion had taken place. Later, the exposed surfaces of the strata were deeply cut by streams. River valleys with all their many branches laid open the rocks deep into the successive strata, so that now the formations of several periods may be distinguished on the steep sides of the deeper valleys.

In addition to the modification of the surface due to the weathering and erosion of the rocks, certain other changes were caused in more recent times by glacial action. It is thought that during the period called the "Glacial Period," most of the area of the United States north of the Ohio River, and also other parts, were at certain times more or less largely covered with a sheet of ice a thousand feet or more in thickness, and which, in a southerly movement, transported loose surface material, greatly modifying the pre-existing surface. On account of this movement the surface in some places bears a thick coat of "drift," which is a heterogeneous mass of clay, sand and boulders. In some places valleys have been filled and courses of streams changed. In other regions valleys have been modified by the deposition of great quantities of gravel, which, having been washed out of the drift, has been swept along by the streams filled to overflowing by the excessive quantities of water coming from rain and melting ice. The gravel de-

posits found along the valley of White River in Jackson and Bartholomew counties, and in the Ohio River terraces, bear evidence of the magnitude of the work of this kind accomplished.

Much of the material found in the drift is not of local origin. Scattered boulders of granite, greenstone, etc., which are found in some places of the region, have been transported to those places from regions far to the northward by the movement of the ice sheet.

In those regions where no drift occurs, notably in Harrison and Floyd counties, the surface is covered from 2 to 15 feet deep with residual soil, the insoluble parts of limestone or the disintegrated material of sandstones and shales. In such regions the gravel found along the small streams is made up wholly of material formed in the rocks of the region. Of course, a larger stream, having its source outside of a driftless region, may bring into that region a certain amount of gravel from the drift deposited along its source. Such instances in this area are, however, rare.

In order thoroughly to appreciate the significance of the different kinds of rock samples sent from this area to be tested for roadmaking, it will be necessary to know something of the names, kinds, order of deposition and extent of outcrops of the different rock formations of the area. The following column of rock succession gives the principal divisions of rock formations occurring therein and corresponds to the grouping given on the geological map accompanying the Twenty-eighth Annual Report of the Indiana Department of Geology.

Lower Carboniferous (Mississippian).	Mitchell Limestone.	
	Bedford Oölitic Limestone.	
	Harrodsburg Limestone.	
	Knobstone Shale.	
Devonian	New Albany Shale.	
	Sellersburg Limestone.	
	Silver Creek Limestone.	
	Jeffersonville Limestone.	
Silurian	Niagara.	
Ordovician	Cincinnati	Richmond.
		Lorraine.
		Utica.
	Trenton.	

The first column gives the age or period, the second the corresponding formations.

Rocks of the oldest formation exposed—the Trenton—are found only in the eastern part of Switzerland County and are very limited in area. This formation is usually struck in the drilling of gas wells and in other parts of this area lies at a depth of from 400 to 800 feet below the surface. None of the Trenton rock is available for quarrying.

The area covered by rocks of the Cincinnati formation is a wide one. It embraces the counties of Dearborn, Ohio, Switzerland and the eastern part of Jefferson. The surface is generally covered with old drift from a few inches to 15 feet in depth, but the rocks are exposed at many places throughout the much eroded region.

The rocks of this formation are limestone, usually hard, blue-gray and highly fossiliferous, being thin-bedded, two to eight inches in thickness, while intercalated between these layers of limestone are beds of soft shale and clay. The shale and clay form a little more than one-half the total thickness of the formation.

The Niagara formation covers the eastern part of Decatur, Jennings and Clark counties and the central part of Jefferson County. It embraces beds of limestone and of clay of varying thickness, amounting to about 125 feet in all. There are many thick-bedded layers. The limestone varies in hardness from comparatively soft to the hardest, firmest and most fine-grained variety. The formation is distinguishable from the Cincinnati formation by the greater thickness of the limestone beds and the less abundance of shale or clay. The firmness and thickness of the strata give a precipitous slope to hills capped by it.

Next west of the Niagara limestone come the limestones of the Devonian period. These embrace the Sellersburg, the Silver Creek and the Jeffersonville limestones. The area covers the western half of Decatur, the eastern margin of Bartholomew, the central part of Jennings, the western part of Jefferson and the central part of Clark counties. It varies in width from two to fifteen miles, the wider portion being toward the north.

The Sellersburg limestone is a grayish-blue, moderately hard, fossiliferous limestone, sometimes with a very arenaceous layer between it and the overlying black shale. Beneath it is a fine-

grained, massively bedded argillaceous magnesian limestone. The Jeffersonville limestone is a white, buff or grayish limestone. In some places it is soft and very fossiliferous, containing many corals. Other parts are hard, firm and crystalline.

Overlying these limestones is the New Albany black shale. This covers an area twelve to fifteen miles wide in the central part of Bartholomew, the eastern margin of Jackson, the western half of Jennings and eastern Scott and western Jefferson counties. It narrows toward the south and passes through central Clark County, where it covers irregularly an area some eight miles wide. The shale is bluish to black in color, fissile, and contains considerable amounts of iron sulphide and bituminous matter.

The Knobstone shale area embraces the western third of Bartholomew County, all of Jackson except the eastern margin and the western halves of Scott, Clark and Floyd counties. The rocks consist of soft sandy shales, greenish gray in color, and moderately hard sandstones. The formation contains much iron oxide, which exists as nodules more or less pure, but in many cases acting as the cementing material of small sand concretions. These nodules and concretions weather out of the looser and softer shales and are washed together by heavy rains, being collected in the beds of streams heading among the hills. This provides one source of road material that has proven very suitable for pike-making.

The Harrodsburg limestone is not very extensive in this area, being found to a limited extent in the western part of Jackson County and over the western part of Floyd County. One characteristic feature of the formation in Jackson County is the occurrence in it of numerous quartz geodes. From the disintegration of the surrounding rock material, the geodes are left in considerable abundance. Heavy rains wash out great numbers of the smaller ones, and they are frequently gathered up with other gravel to be used on roads.

The Bedford oölitic limestone occurs in the southwestern part of this area, in narrow outcrops in Floyd and Harrison counties. This limestone is a thick-bedded, moderately soft, even-textured oölitic limestone, and is well known throughout the United States as a building material.

The Mitchell limestone occurs in this area chiefly in Harrison

County. It is largely a compact, drab-colored limestone, resembling lithographic limestone in texture. It occurs in comparatively thin beds, which are traversed with many open joints, so that the stone can not be obtained in large pieces. It makes a good road metal, but has not been used extensively in this area. This stone is characteristically distinguished by a cavernous structure, and the surface bears the sink-hole type of topography. The upper portions contain considerable quantities of chert, which is left scattered through the residual soil as the limestone becomes disintegrated.

Present Conditions.

That portion of Indiana covered by the writer and treated in this section has for the most part a yellow clay soil at the surface. While varying in quality in the different parts of the area it is, on the whole, a soil poorly adapted to making good roads. If much traveled in wet weather it becomes very miry, and does not quickly become smooth after it is dry. Added to this is the fact that in much of the region the surface is comparatively level. In such regions under-drainage is very slow, owing to the impervious nature of the sub-soil, and water stands many days after a rain. Conditions would be bad enough if the roadbed were well graded and drained. But, as a matter of fact, few dirt roads are carefully treated in this way. The result is that the roads are almost impassable during much of the winter and spring seasons. The conditions of the dirt roads are probably not so bad as they were when the country was heavily forested and little or no drainage had been done. The effect of excessive shade upon roads is very well shown in places where trees are now growing near the road.

But there is progress toward better conditions. The vast resources at hand for building pikes are beginning to be utilized. Permanent roads, of good quality, are taking the places of the inferior dirt roads. Wherever a start has been made the farmers are quick to see the advantage of such improved roads and they are willing to take steps toward extending them.

In no county of the area is there an absence of rock or of gravel in great enough abundance to supply all the roads in these counties, while in some counties material is unlimited in amount.

There is one feature of road-making operations that seems to prevail in every part of this region, and which is a considerable drawback to the best results in road-making. This is the unscrupulousness of road contractors. The pikes are very frequently poorly constructed and do not fairly represent the possibilities of road construction in the region. In almost every county visited by the writer he found some instance of dishonest construction of road and manipulation of county commissioners, who are responsible for the proper completion of road contracts.

Kinds of Road Metal.

In the building of pike roads in this area a great variety of material is used. Limestone, shale, several kinds of gravel, and sandstone—one or the other—are used more or less, according to their relative abundance in the vicinity of the improved road. We shall briefly consider each of these in regard to its distinctive features and qualities as a road metal.

Limestone.—Of all materials found in the region, limestone is the most abundant and the best material for roads. It is found in greater or less amount in every county within the area. The only county in which it is not used to any great extent is Jackson. It occurs in great variety of hardness, texture and composition. In some places it is quarried with some difficulty, owing to its depth below the surface. In many places it is a common outcrop and occurs, in great enough abundance for use, as loose pieces in fields and on the hillsides.

In its preparations for road metal, it may be crushed by machinery or is broken up into the desired size by hammer. Many people hold that the rock broken by hand is preferable to that broken in a crusher. This theory is not clearly substantiated in the opinion of others.

Shale.—In some parts of the area, where limestone is not available and gravel is too scarce for use in building pikes, recourse has been taken to the next best material found in those regions. The New Albany black shale ("slate") has lately come into prominence as a road metal. For some time it was thought to be unsuited for this purpose. As to its wearing qualities, something will be said when those counties where it is used are considered. This shale is not used to a great extent.

Gravel.—There is considerable variety in the kind of gravel that is found in different parts of the area and that is used on roads. The two most important kinds are the gravel of glacial stream deposits and the gravel of the Knobstone hills.

Bank Gravel.—Along the Ohio River valley in many places, from Lawrenceburg to New Amsterdam, extensive deposits of gravel are found. This gravel was deposited in terraces, two or three in number, where the Ohio River flowed with greater volume and at a higher level than at present. The lower terraces—some 30 and 45 feet above the river at ordinary stage—are overflowed in time of high water. The gravel where it occurs in the lower terraces is covered from 8 to 40 feet deep with fine silt.

The highest terrace—some 60 feet above the river—is not deeply covered with silt; often the gravel appears within two or three feet of the surface. Other streams have gravel deposits along their courses, notably the Whitewater and the White Rivers, flowing out of the newly glaciated regions lying to the northward. On the Whitewater, the gravel deposits are mainly in the higher terrace, while on the White River both high and low terraces produce gravel. The gravel region of White River is very extensive, as is shown by the map.

Iron Oxide Gravel.—The most abundant gravel found in creek beds is the reddish sandy gravel of the Knobstone region. This gravel is composed of concretions of iron oxide which contain more or less sand, sometimes the oxide being quite free from sand, sometimes the sand being the major part. The gravel is derived from the shales, from which the concretions are washed as the shales are disintegrated. This gravel is found mainly within two miles of the hills and is comparatively more abundant in the smaller runs or branches than in the larger creeks.

Bar Gravel.—Much of the course of the Ohio River, where terraces are found, has a gravelly bank, and gravel bars appear in the river when it is at a low stage. This gravel is similar to that found in the terraces, but is coarser and has less sand and clay intermingled.

Red Flint Gravel.—In a few localities is found a gravel which is made up largely of cherty fragments, with some iron oxide. Decatur and Jefferson counties have a limited amount of gravel of this kind.

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Limestone Creek Gravel.—In certain localities where short valleys open into the Ohio valley much limestone is washed from the neighboring hills and is collected at the mouths of small runs or in the lower part of their beds. This gravel is coarse, ranging in size from pieces an inch in diameter to those six inches in diameter.

Chert and Limestone Gravel.—In Harrison County a gravel occurs in creek beds. It is composed mainly of chert and limestone particles, derived from rocks of the region. Also in Jefferson County occurs a limited amount of this kind of gravel.

Sandstone.

Where other better material is wanting, sandstone has been used as a road metal. This has been done to a small extent in Jackson County. Sandstone, being quite easily crushed by travel upon the roads, is of doubtful adaptability to permanent road making. Some results of its use as such will be found under the discussion of Jackson County roads.

DEARBORN COUNTY.

Area in square miles	309
Population in 1900	22,194
Miles of public roads	255
Miles of free improved roads	None
Miles of toll improved roads	20
Toll roads constructed	1830 to 1860
Authority	Albert T. Gridley, C. E.

"About 60 miles of road in the county have been improved by the farmers clubbing together and putting broken stone on six inches deep and nine feet wide, without grading or drainage. Our commissioners have been able to defeat every attempt of the people to convert the township roads into free improved county roads, the auditor giving them ready assistance. That is why we have no improved roads."—A. T. G.

With unlimited quantities of material for road making, Dearborn County is one of the least advanced with good roads. Along the Whitewater River there is much gravel in terraces on either side of the river. Throughout the county limestone occurs, cropping out on the hillsides, while in the level northwest portion it occurs in most of the stream beds. There are about 70 miles of improved roads in the county. Much gravel occurs in the channel

of Whitewater River. This is utilized to some extent. Limestone of a hard variety, bluish in color and quite fossiliferous, occurs within eight or twelve feet of the surface of all the upland in Miller, Harrison, Logan and Kelso townships. It is easily accessible in all parts. In ravines it may be gathered up in the form of boulders washed down by the water. In this form it is taken by the farmers to the crushers and then is placed on the road where it seems to be the most needed. This county also has a considerable amount of Ohio River terrace gravel.

Much of the road throughout Logan and Kelso townships has been scattered with a thin covering of large rock, three to five inches in diameter. This can scarcely be said to be an improvement, as the road is thus made intolerably rough. No contract work has been done. Even the roads the most traveled are in a deplorable condition. With the present methods the roads of this region will remain unserviceable for many years, and will never be as good as they might be had they been properly built from the start.

Local Deposits Available for Future Use.

Frank Volz.—Southwest quarter section 10 (5 N., 1 W.), Lawrenceburg Township. At the northwest edge of the city of Lawrenceburg an excavation has been made in the high terrace. Gravel has been used from this pit for many years. At the top is soil two to three feet thick. Below this are sand and gravel, alternating with layers of fine silt. The material is rather fine for roads and must be sifted to remove the finer portions, which comprise the greater part of the whole. There is no gravel larger than one and a half inches in diameter, and very little as large as that. The most of what was left after sifting would average one-fourth to one-half inch in diameter. About 25,000 cubic yards have been removed. Four acres are remaining.

Joseph Burkheim.—Southwest quarter section 36 (6 N., 1 W.), Lawrenceburg Township. Here is a gravel pit 100x75 yards in area. The soil at top is three to four feet deep, and there are 25 feet of gravel, one-half to one and a half inches in diameter. The pike from here to Lawrenceburg has been kept in repair from this pit for the last 50 years. This deposit is at the end of a small

ravine leading down into the Miami valley near its junction with the Ohio River valley, and continues in a northeasterly direction, more or less interruptedly, for one-fourth of a mile. The top is about 40 feet above the low terrace, which forms the "bottom land" of the vicinity. At about 12 feet from the top there is a stratum 2 to 16 inches thick, cemented with calcareous cement. This stratum extends horizontally through part of the deposit and crops out on one side of the hill. On the opposite side of the ravine a similar deposit of gravel is found, which also contains a cemented layer.

Mary Rogers.—Northwest quarter of southwest quarter of section 35 (6 N., 1 W.), Lawrenceburg Township. An abandoned limestone quarry is situated near the top of a high bluff which overlooks the Ohio valley, two miles northwest of Lawrenceburg. A section of the quarry shows about 25 feet comprising a hard, drab-colored limestone containing many fossils, and intercalated layers of soft shale or clay. The limestone varies in thickness from 1 to 12 inches, and includes about half the whole thickness of the section. The stone would be good for roads. A large amount of stripping would, however, be necessary in order to utilize any great portion of the quarry. About 5,000 cubic yards would be available, with 2 to 6 feet stripping.

At Bright.—Southwest quarter section 35 (7 N., 1 W.), Harrison Township. Limestone is 6 to 15 feet below the surface. At several places near here gravel was reported to have been found underneath the limestone. Mr. G. H. Gibson stated that his father dug a well in 1823, passing through ten feet of soil, six feet of limestone, then "blue clay." Underneath this was gravel. Water was a year coming in; then came in in one night. Since that time it has been a never-failing water supply. This well is located on the northwest quarter of section 3 (6 N., 1 W.), Miller Township.

Henry Simonson.—Northeast quarter section 25 (7 N., 1 W.), Harrison Township. About a mile southwest of Harrison, Ohio, there is a gravel pit near the road and in the edge of a double terrace on the right side of Whitewater valley. The upper terrace is about 60 feet above the river bottom. The second terrace is 15 feet lower. Both of the terraces seem to be made up largely of gravel. The upper one is about 200 yards long and 40 yards

wide. The lower is about 175 yards long and 50 yards wide. The lower terrace is cut by two gulches, which expose the gravelly exterior. Some gravel has been taken out and the pit is being used at present.

Section of gravel pit on land of Henry Simonson, Dearborn County.

		Feet.
1.	Soil	1 to 2
2.	Coarse gravel (½ to 2 inches in diameter)	10
3.	Fine gravel and sand	10

The top of the exposure is 25 or 30 feet below the top of the upper terrace, which may be considered to be made up of coarse gravel. It is probable that all of these two terraces would be available. This piece of terrace, like that on the Burkheim property, is situated above the mouth of a small valley leading into the Whitewater River from the west. It is a common thing to find just such gravel terraces on the upper side and at the mouths of tributary valleys. The cause for this is easily attributable to the fact that a large volume of water, flowing at a high level in the larger valley and bearing quantities of gravel in its current, would have its current checked by the entering stream of the tributary valley and would consequently drop some of its load at that point. Such an occurrence of gravel may be noticed at the junction of many tributary streams along the Ohio River, and when any terrace is noticeable at such places it is very likely that gravel is contained within it.

Charles Otto.—Southeast quarter section 12 (7 N., 1 W.), Harrison Township. Here a gravel terrace extends for a mile or more northwest from Harrison, Ohio. It is about 40 feet above the Whitewater River bottom. This part is 150 yards wide and 200 yards long. No gravel has been removed, but places on the side of the slope show gravel one-half to two inches in diameter. It is practically the same kind as is found at the Simonson pit.

Charles F. Frizelle.—Southwest quarter of section 12 (7 N., 1 W.), Harrison Township. The terrace extends from the Otto farm to about a quarter of a mile west of this farm house. Here it is nearly a quarter of a mile wide and it has gradually lowered in level from the Otto place, being about 20 feet above the river bottom.

Catherine Stenger.—Southeast quarter of section 10 (7 N., 1 W.), Harrison Township. At this place are two gravel terraces.

The first is about 50 feet above the bottom land, is 150 yards wide and a quarter of a mile long. The second terrace is about 20 feet lower and is 50 by 150 yards in area.

The frequent occurrence of gravel along this pike furnishes a ready material for use thereon. It makes a good road metal, although, during a dry time, it loosens up considerably.

M. V. Fox.—Northwest quarter of section 10 (7 N., 1 W.), Harrison Township. A gravel terrace extends for about one-fourth of a mile, and with a width of 20 to 40 rods. It is about 25 feet above the bottom land. Twenty-five feet above this terrace a narrow strip of terrace, one to ten rods in width, clings to the sides of the steep limestone bluffs.

G. H. Meyer.—Northeast quarter of section 5 (7 N., 1 W.), Harrison Township. On this place there is an extensive widening of the high terrace. About a half mile southeast of the house the wagon road leaves the valley of the Whitewater and passes up a small ravine to the northwest toward Trenton. The terrace is here about one-fourth of a mile wide, and more than that in length in Dearborn County, extending into Franklin County.

John D. La Croix Estate.—Southwest quarter of section 4 (7 N., 1 W.), Logan Township. A portion of a low terrace 25 feet above the bottom land and 40 feet above the river bed, extends for half a mile with a width of 10 to 15 rods. About 15 feet higher up another terrace appears, and this extends back from the river 20 to 30 rods.

Frank H. Viel.—Southeast quarter of section 14 (7 N., 1 W.), Harrison Township. The gravel terrace, which for about two miles has been scarcely represented, here widens out to one-fourth mile in width and extends for a mile or so down the valley. Some cemented gravel occurs here.

Dair Bros.—Southwest quarter of section 13 (7 N., 1 W.), Harrison Township. Just east of Viel's place both terraces appear. The lower is about 40 rods wide and extends as far east as the point where the road forks, one branch running south up the hill, the other running east to Harrison. The upper terrace is 40 rods wide and extends some 50 rods farther down the valley.

In the valley of Tanner's Creek and those of its branches limestone crops out on the hillsides.

At New Alsace, limestone occurs under about 10 feet of soil and glacial drift. About a mile and a half west of New Alsace, on a branch of Tanner's Creek, northeast quarter section 31 (8 N., 3

W.), limestone is found in the creek bed. There is also an outcrop on the hill 10 to 20 feet above the creek and on the road a short distance west of the stream. It is a hard, fine-grained limestone, with few or no fossils. Above this is a coarse-grained fossiliferous limestone.

At Lawrenceville, a limestone outcrops in the sides of the valleys near town. Also about two and a half miles south of Lawrenceville, northwest quarter section 30 (8 N., 3 W.), a fine-grained, hard limestone outcrops in the bottom of a ravine by the road. The outcrop is about 20 feet below the general level of the surrounding country. By stripping one to eight feet, two or three acres would be uncovered. Similar conditions might be found in many parts of this locality, although it is high land, not cut by deep valleys.

John Wiesahan.—South part of the southwest half of section 6 (6 N., 2 W.), Jackson Township. Limestone crops out in many places on this farm and there are at least 20 acres which would be available with two to three feet of stripping. The rock, as is common in this formation, is generally thin-bedded, two to ten inches thick, possibly some 18 inches thick. It is of hard quality and well suited to pike making. The rock is easily quarried, being interbedded with soft shale. A few instances were noticed where this kind of rock had been used on roads. Some parts were in good condition; others were quite dusty, due probably to an excessive application of dirt. But as no properly constructed road has been made, it is difficult to form a fair estimate of the suitability of the rock for road making.

Samples of stone from one of the outcrops were secured and sent to Washington, D. C., for testing in the U. S. Road Laboratory. The results of the physical test were as follows:

*Results of Physical Tests of Ordovician Limestone from the land of John Wiesahan, Weisburg, Dearborn County.**

Specific gravity	2.7	French coefficient of wear	8.3
Weight per cu. ft. (lbs.)	168.4	Hardness	2.5
Water absorbed per cu. ft. (lbs.)	.62	Toughness	8
Per cent. of wear	4.8	Cementing value—Dry	44
		Wet	59

"Below the average in hardness and toughness for limestone, and about the average in resistance to wear, with good cementing value. Excellent for highway and country-road traffic."—Page.

*For standard of comparison see p. 79.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Ordovician Limestone from the land of John Wiesahan, Weisburg, Dearborn County.

	Per cent.
Alumina (Al_2O_3)	.80
Iron oxide (Fe_2O_3)	.51
Lime (CaO)	52.65
Magnesia (MgO)	.50
Phosphoric acid	.10
Insoluble in hydrochloric acid	5.03
Loss on ignition	40.69
Total	100.28

In this part of the county rock can be obtained within a hauling distance of two miles, while for few roads would it be necessary to haul for more than one mile. The rock is near the surface, and a stripping of two feet would lay bare unlimited amounts of limestone.

Terraces of silt extend up the creek valleys six or eight miles, but no gravel occurs corresponding to the gravel deposits of the Ohio valley.

On the divide between Tanner's Creek and North Hogan Creek, the limestone is six to ten feet below the surface, decreasing in depth as the slopes of the valleys are reached. Rock could be obtained in any part of Manchester Township on the level upland at a depth of six to ten feet, or by hauling from the hillsides not more than two miles. No quarries exist, as it is easy to obtain what is needed from the hillsides and valleys.

The roads in this township (Manchester) are in very poor condition, none being piked except the road from Lawrenceburg to Manchester. Some broken rock has been placed in spots, but has only resulted in making a very rough road.

From Moores Hill to Dillsboro, thence through the southern part of Dearborn County to Aurora, limestone is abundant and easy of access for quarrying. South Hogan Creek abounds in fragmentary rock, which has been brought by the water. The hills above South Hogan Creek are full of rock from the top to the creek level, some 175 feet below. Hard limestone, fine-grained, gray-blue, one to six inches thick, alternates with soft blue shale. These condi-

tions make not only greater ease in quarrying, but give a rock of suitable size to run into the crusher.

Thomas Croxton.—Northwest quarter of section 7 (4 N., 3 W.), Clay Township. Limestone outcrops on South Hogan Creek near the B. & O. S. W. Railway station at Dillsboro. A number of thick beds of a hard, bluish gray limestone reach from the water's edge to the top of the bank. None has been used for road material. The amount available is unlimited. A sample of stone secured from a ledge about six feet above the water was sent to Washington, D. C., for testing in the U. S. Road Laboratory. The results of the physical test were as follows:

*Results of Physical Tests of Ordovician Limestone from the land of Thomas Croxton, Dillsboro, Dearborn County.**

Specific gravity	2.7	French coefficient of wear	8.3
Weight per cu. ft. (lbs.)	168.4	Hardness	9.8
Water absorbed per cu. ft. (lbs.)	.78	Toughness	7
Per cent. of wear	4.8	Cementing value—Dry	67
		Wet	100

"A rather hard limestone, somewhat low in toughness; of average resistance to wear and excellent cementing value. Should give excellent results under highway and country-road traffic."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Ordovician Limestone from the land of Thomas Croxton, Dillsboro, Dearborn County.

	Per cent.
Alumina (Al_2O_3)	.76
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	52.20
Magnesia (MgO)	.50
Insoluble in hydrochloric acid	5.45
Loss on ignition	40.36
Total	99.52

The pike from Dillsboro to Aurora has been built 50 years. It is one of the smoothest roads in all the area traversed. Even in the dry time in which it was viewed it had a hard surface, with very little dust. It was built from rock picked up from the fields

*For standard of comparison see p. 79.

and valleys in the vicinity. The rock was broken up by hammer and the grades are moderate and not badly washed.

Thomas Baker.—Northeast quarter of section 29 (5 N., 1 W.), Center Township. About a mile and a half north of Aurora there is a small portion of terrace from which gravel has been removed. Some 15,000 yards have been taken out. The deposit lies like a delta in the mouth of Wilson Creek.

Section of gravel pit on land of Thomas Baker.

		Feet.
1.	Loess-like, buff colored silt	4 to 10
2.	Fine gravel (1-16 to ¼ inch diameter)	6
3.	Coarse gravel (¼ to 1 inch diameter)	6
4.	Coarse sand	2+

The deposit extends back some 40 rods, but since there is such a great depth of silt, not much more gravel can be taken out readily. Gravel is not used to a great extent in this vicinity.

A continuation of this terrace north of Wilson's Creek and east of the wagon road may contain gravel. No other gravel deposits appear between Aurora and Lawrenceburg.

In the Ohio River north of Aurora there is a gravel bar about a mile long and some 20 rods wide, averaging three feet deep, which is accessible only at low water in the river. This gravel is used on the streets in Aurora for concrete work, etc.

River View Cemetery.—Northwest quarter of section 9 (4 N., 1 W.), Center Township. Just north of the wagon bridge over Laughery Creek there is an extensive gravel terrace, part of which is occupied by the River View Cemetery. The terrace is about 60 feet above the Ohio River. Gravel occurs in irregular deposits. In some places it is coarse, in others it is as fine as sand. A well dug for cemetery purposes shows a section of 16 feet of soil and 100 feet of gravel.

Mr. Nevit.—East half of section 8 and west half of section 9 (4 N., 1 W.), Center Township. This is an extension of the same terrace as the above. The terrace extends west from the road about three-quarters of a mile on the north side of Laughery Creek, with a width of about one-fourth of a mile. Some 125 acres are probably underlain with gravel.

OHIO COUNTY.

Area in square miles	87
Population in 1900	4,724
Miles of public roads	160
Miles of improved roads	35.5
Percentage of roads improved	22.2
Miles improved with gravel	4
Miles improved with crushed stone	31.5
Average original cost of gravel roads per mile	$1,200
Average original cost of stone roads per mile	$1,964
Total original cost of improved roads	$66,671
Annual cost of repairs per mile on gravel roads 5 years old	$100
Annual cost of repairs per mile on stone roads 5 years old	$100
Miles of improved roads (stone) built in 1905	2.75
Miles of improved roads contracted for 1906	None
First improved roads built	1869
Number of miles of toll roads yet in operation	10
Proportion of improved roads built since 1895 (per cent.)	50
Satisfaction of farmers with investment in improved roads—	"The majority are well satisfied."
Authority	Jas. W. Corson, County Auditor

Ohio County is similar to Dearborn in regard to the amount of available rock and the ease of obtaining it. The county is only fairly provided with pikes. Some important roads between villages are in the poorest condition imaginable.

A rock road running west from Rising Sun about seven miles was mainly completed in 1893. Some parts were built recently and have not become packed. It is now in good condition most of the way. It follows the valley of Arnold Creek and was constructed of loose rock obtained all along the route.

There is a pike, mainly of gravel, six miles in length, leading from the northwest corner of section 33 (4 N., 2 W.), Union Township, along the south side of Laughery Creek toward Aurora. It is a fairly good road, but the gravel used was rather fine, averaging about one-fourth inch in diameter, with considerable sand. A portion of this road has a rock bed topped with gravel. The gravel forms a good surface, but washes badly on the hills.

A gravel pike runs from Rising Sun northward to meet the pike in Dearborn County running to Aurora. It is in poor condition, being rough and muddy in a wet time.

A good stone pike runs from Rising Sun to Aberdeen, a distance of about nine miles. It has been built for many years.

Gravel occurs in Laughery Creek from the mouth of South Fork to near the mouth of Laughery Creek. The bars are sometimes as large as 100 yards long by 5 yards wide. The material is rather coarse, ranging in size from one-fourth inch to three inches in diameter. No bank or terrace gravel was observed along this creek. The amount of available gravel would not be sufficient for all roads in the vicinity, but since the hillsides are all filled with rock there would be no need to depend on the gravel.

Ohio County is much cut by valleys, and there is no place in the whole county where good limestone for roads may not be quarried within one-half mile of the place where it is needed. The soil is 6 to 15 feet deep on the upland, and diminishes in depth toward the slopes. The rock crops out on the sides of all ravines. Quarrying is not necessary, since it is easier to gather the loose rock from the surface, even though by so doing a little longer haul is made.

Ohio River terrace gravel occurs in abundance in the vicinity of Rising Sun. The upper terrace, some 60 feet above the river, begins at the northern edge of Rising Sun and extends some two miles to a small creek on B. B. Loring's farm, southwest quarter of section 26 (4 N., 1 W.), Randolph Township, where there is a small gravel pit. This terrace averages one-half mile in width, narrowing toward the north and the south.

As usual in the high terraces, the gravel is quite near the surface. About 15 feet lower is another terrace, lying along the eastern and southern sides of the upper terrace. This terrace extends about a mile and a half farther down the valley and lies beneath most of the town of Rising Sun. The relative boundaries of these gravel terraces may be seen on the map. Excavations made in Rising Sun show the gravel to be from three to four feet below the surface in the second terrace and 24 feet below the surface on the lowest terrace, which is some 30 feet above the river.

Dry Branch Creek, at a point about 40 rods north of the city limits, has cut into the terraces and has washed much gravel out into its channel. This gravel covers the bottom of the creek, thus obscuring the little water that is in it and giving rise to the name of the stream.

Henry Schroeder.—Southwest quarter of section 34 (4 N., 1 W.), Randolph Township. A sample of limestone from this farm

was tested at the U. S. Road Laboratory, with the results shown in the table. This is practically the same rock that is used all over the county, where roads are being built of stone, and the quantity is unlimited.

Results of Physical Tests of Ordovician Limestone from land of Henry Schroeder, Ohio County.

Specific gravity	2.7	French coefficient of wear	7.3
Weight per cu. ft. (lbs.)	168.4	Hardness	4.7
Water absorbed per cu. ft. (lbs.)	.46	Toughness	9
Per cent. of wear	5.5	Cementing value—Dry	15
		Wet	98

"A soft limestone of average toughness with a low resistance to wear, but with a good cementing value. Suitable for light traffic or as a binder in connection with harder material."—Page.

A chemical analysis of the sample, made at the same laboratory, showed the following results:

Chemical Analysis of sample of Ordovician Limestone from land of Henry Schroeder, Ohio County.

	Per cent.
Alumina (Al_2O_3)	.73
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	53.15
Magnesia (MgO)	.63
Phosphoric acid (P_2O_5)	.38
Insoluble in hydrochloric acid	2.92
Loss on ignition	41.90
Total	99.96

SWITZERLAND COUNTY.

Area in square miles	225
Population in 1900	11,840
Miles of public roads	345
Miles of improved roads	108
Percentage of roads improved	31.3
Miles improved with gravel	28
Miles improved with stone	80
Average original cost of gravel roads per mile	$1,300
Average original cost of stone roads per mile	$1.800
Total original cost of improved roads	$180,400
Annual cost of repairs per mile on gravel roads 5 years old	$50
Average cost of repairs per mile on stone roads 5 years old	$70
Miles of improved roads built in 1905	None

Miles of improved roads contracted for 1906	**None**
First improved roads built	**1851**
Proportion of improved roads built since 1895 (per cent.)	**80**
Satisfaction of farmers with investment in improved roads	**Good**
Authority	**L. J. Woollen, County Auditor**

A number of miles of pike road have been built in Switzerland County during the past five years, and the county compares very favorably in the amount of improved roads with the other counties of the area under consideration. The extent of limestone available for road-making is unlimited. The rock formation is in the eastern part, similar to that of Dearborn and Ohio counties; in the western part higher formations appear. The surface is also like that of those counties, being much dissected by valleys. The outcrops of rock are very numerous on the hillsides, while much rock is washed down into the stream beds. In the northern part, where the surface is more level and less cut by valleys, the limestone does not appear at the surface; but it is usually not over eight or ten feet below.

There are probably greater deposits of gravel along the Ohio River in this county than in any other county of this area. On none of the smaller streams is there found gravel worthy of mention, although many of them contain loose stones of a size varying from one inch to ten inches in diameter. No great use has been made of these extensive river deposits, and for part of the way the "river road" itself has not received the benefit of a gravel top.

At the mouth of Grant's Creek, northwest quarter of section 27 (3 N., 1 W.), Posey Township, there is a portion of terrace which may contain gravel. Its position at the mouth of Grant's Creek valley would indicate this. There are about three acres in the deposit here.

Near the middle of the west half of the southwest quarter of section 30 (2 N., 1 E.), Posey Township, lies the north end of a large tract of terrace gravel. This point is about 30 rods west of the Gibson house and just west of the mouth of a small creek. The area embraces a high terrace, about 60 feet above the river, and lower terraces. The eastern limit is the Ohio River. The western limit passes just east of the high rocky bluffs running south through the middle of section 31 (2 N., 1 E.), southwest through the west half of section 6 (1 N., 1 E.), and through the

western part of section 7 (1 N., 1 E.), meeting the river about half a mile northeast of Patriot. This area comprises about three sections of land. The gravel may be found at a depth of from one to four feet. It is of good quality, and in size ranges from one-fourth of an inch to two inches in diameter. In some places a few large stones, five to eight inches in diameter, occur. The gravel is mostly limestone, but a considerable portion is shale, greenstone, flint, etc.

Almira Abbott.—Section 7 (1 N., 1 E.), Posey Township. A large gravel pit occurs by the roadside about one and a half miles northeast of Patriot. About 150x30 yards, 20 feet deep, have been removed. The gravel ranges in size from one-fourth of an inch to two inches in diameter, and the deposit is covered with from two to four feet of soil. Gravel is being hauled from this pit for the repair of the pike in this vicinity.

One of the least improved parts of the river road in this county lies directly over the rich deposit of gravel near the Gibson place. Through sections 25, 36 and 35 (2 N., 1 W.), the roads have not been graveled. The tract of gravel above referred to averages at least 50 feet in depth, or what would equal 150,000,000 cubic yards.

An area two or three miles south of Patriot, including parts of sections 30 and 31 (1 N., 1 E.), and parts of sections 25, 35 and 36 (2 N., 1 W.), as shown on the map, does not strictly produce gravel, but it is underlain by gravel at a depth of from 12 to 40 feet. Gravel bars occur along the river in this locality, and from these it is obtained for roads in the neighborhood. At low water the gravel appears as a gently sloping beach rising from the water's edge to a width of five to ten rods. The gravel contains many pebbles of black shale and greenstone, some granite and some limestone. This river gravel contains little cementing material, and, as a rule, does not pack well on roads.

At Vevay the high terrace has a width of nearly half a mile, while the lower terrace is much narrower. There is an extension of this terrace for most of the distance between the mouths of Indian and Plum creeks. This higher terrace is not overflowed by the river in its highest stages. At the west edge of town there is an old gravel pit in the edge of the terrace, containing about ten

feet of silt and 50 feet of gravel. The pit is not in use now. In size the gravel varies from one-fourth inch to two inches in diameter.

Amy Golay.—South half of section 7 (1 N., 2 W.), Jefferson Township. A gravel pit in the edge of the terrace just east of the mouth of Plum Creek shows 8 to 10 feet of bluff silt above 12 to 15 feet of gravel. The gravel is good, one-fourth inch to one inch in diameter. About 6,000 yards have been removed. There is an unlimited amount left. Here, as in some other places, there are cemented portions. In some places of this exposure there is a six-foot layer of sand between the silt and the gravel.

East of Plum Creek the high terrace extends only about one-fourth of a mile. From there to Markland the river generally keeps near the bluffs. At Markland the middle terrace begins and extends toward Florence, gradually rising to the height of the highest terrace near that town. It is about half a mile wide.

Will Armstrong.—Northwest quarter of section 6 (1 N., 1 W.), York Township. The only gravel pit observed in this neighborhood has been opened on this farm in a field about half a mile below Florence. The pit is in the edge of the upper terrace. About 15,000 cubic yards have been excavated. The gravel is coarse and fine, with much sand. About five miles of road have been graveled from this pit. It was used on roads between Markland and Florence, north of Markland and north of Florence. It is too sandy to make good roads. There are about ten feet of silt on top of the gravel.

Mr. Bodey.—Parts of sections 26 and 35 (2 N., 1 W.), Posey Township. A gravel pit is located on the east side of this farm, about one-half mile from the Ohio River. It is on the highest terrace, which extends eastward, embracing the larger part of the bottom land in this bend of the river. The gravel is one-quarter of an inch to an inch in diameter. This pit is not used now, owing to the fact that the gravel became too fine for road making, and was rejected for that purpose.

Mrs. Abbie North.—Part of section 31 (1 N., 1 E.), and part of section 36 (2 N., 1 W.), Posey Township. About one-fourth mile northeast of this farm house a terrace begins, and, rapidly widening as the bluffs retreat to the west, extends about two miles

western part of section 7 (1 N., 1 E.), meeting the river about half a mile northeast of Patriot. This area comprises about three sections of land. The gravel may be found at a depth of from one to four feet. It is of good quality, and in size ranges from one-fourth of an inch to two inches in diameter. In some places a few large stones, five to eight inches in diameter, occur. The gravel is mostly limestone, but a considerable portion is shale, greenstone, flint, etc.

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Mrs. Abbie North.—Part of section 31 (1 N., 1 E.), and part of section 36 (2 N., 1 W.), Posey Township. About one-fourth mile northeast of this farm house a terrace begins, and, rapidly widening as the bluffs retreat to the west, extends about two miles

southwestward to the neighborhood of the Bodey farm and to the river on the south.

At the mouth of Indian Creek some very coarse gravel has been washed down. This would require crushing in order to be used on roads.

In other parts of the county there is scarcely enough gravel to be worth mentioning. A small amount is obtainable on Indian Creek, south of Aaron postoffice. It is used to some extent in repairing roads in the vicinity.

From Vevay to Bennington there is a good pike. It was built 20 or 30 years ago from rock gathered up near at hand. The pike is smooth and is kept in good repair as occasion requires. There is no place where rock need be hauled over half a mile, since limestone occurs throughout all the region.

George Hotchkiss.—Southeast quarter of section 9 (5 N., 12 E.), Pleasant Township. In this region limestone comes to within four to ten feet of the surface. Rock was quarried on this farm, it being taken from near the top of the divide between Indian and Indian-Kentuck creeks. The rock is found in beds of six inches to four feet thick. Five thousand loads were quarried for pike. Two hundred acres are easily available on this farm and the farms of H. B. Voris and James S. Paully.

Samples of rock from this deposit were secured and sent to Washington, D. C., for testing in the U. S. Road Laboratory. The results of the physical tests were as follows:

Results of Physical Tests of Niagara Limestone from the land of George Hotchkiss, Soapville, Switzerland County.

Specific gravity	2.7	French coefficient of wear	9.9
Weight per cu. ft. (lbs.)	168.4	Hardness	.3
Water absorbed per cu. ft. (lbs.)	.8	Toughness	9
Per cent. of wear	4	Cementing value—Dry	10
		Wet	20

"A rather soft rock, about the average for toughness in limestone, with fair resistance to wear, but rather low in binding power. Best suited for country-road traffic."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Niagara Limestone from land of George Hotchkiss, Soapville, Switzerland County.

	Per cent.
Alumina (Al_2O_3)	.63
Iron oxide (Fe_2O_3)	.51
Lime (CaO)	49.55
Magnesia (MgO)	3.46
Phosphoric acid (P_2O_5)	.26
Insoluble in hydrochloric acid	6.24
Loss on ignition	39.28
Total	99.93

"The insoluble portion is clay."

Mrs. S. F. Harper.—East half of the southwest quarter of section 9 (5 N., 12 E.), Pleasant Township. A limestone quarry has been opened and about 3,000 cubic yards have been removed. The following section is exposed.

Section of Quarry on land of Mrs. S. F. Harper.

	Feet.	Inches.
Soil	..	6
Disintegrated limestone and shale	8	..
Hard greenish-purplish colored limestone in layers 6 inches to 2 feet thick	12	..

The rock is not largely fossiliferous, but is fine-grained and hard. The outcrop is on the side of a small valley about 30 rods northwest of the farm house, and is easy of access. This rock has been used on a new pike toward the north line of the county. Eighty acres are available. The upper part of this rock is similar to the sample tested from the Hotchkiss quarry.

O. M. Copher.—Northwest quarter of section 9 (5 N., 12 E.), Pleasant Township. A section of rock from the top layer exposed on this farm to the formation outcropping in the middle part of Mrs. Harper's quarry is as follows: The upper layer is a soft-medium, sandy limestone, yellowish in some parts; drab-colored in others. Below this is a friable limestone, somewhat fossiliferous, gray colored, rather coarse texture, cracking on exposure to sun and weather. This layer is similar to that from which the sample from the Hotchkiss farm was taken. Below this is a fine-grained, blue-purple limestone similar to the rock at the base of the Harper quarry.

About the middle of section 11 (5 N., 12 E.), where a small valley crosses the road, the interbedded thin limestone and soft

shale outcrop. Also in the bed of a branch of Bear Creek, which crosses the pike at a point about half way between the church and Mr. Cooper's place, the same shale-limestone formation appears. This is the same as most of the upper formation of Ohio County. It is probably the Lorraine formation. It seems to be not far below the thick-bedded limestone of the quarries just described.

In the region of Aaron postoffice is a flat "divide," where rock does not appear at the surface. About half a mile southeast of Aaron, where the road branches, rock outcrops on the hillside and in the bed of a small valley. This could be quarried, with one to three feet of stripping, over a large area.

Harry Blodget.—East half of northwest quarter of section 3 (3 N., 3 W.), Cotton Township. On this farm, in making a cistern 12 feet deep, rock was penetrated several feet. This was on the level highland divide between the valleys of Laughery Creek and the Ohio River. Across the road from this place rock was struck in a well at a depth of 12 feet. The divide here is about three-fourths of a mile wide.

About 40 rods east of Fairview, near the head of Sugar Branch, and on the hill between the creek and the village, rock crops out in the road. One to two acres could be laid bare with one to three feet of stripping. Much could be obtained with one to four feet of stripping.

From Fairview to East Enterprise many small valleys cut the road and rock outcrops on the sides of all these valleys.

The road from Soapville to East Enterprise is not improved, though it is a much traveled road. From East Enterprise a good pike leads to Patriot by way of Quercus Grove.

Rock for the East Enterprise end of this pike was obtained from the Dunning farm east of town. On the upland level rock is from 10 to 15 feet below the surface and crops out in many valleys.

George W. Oaks.—Northwest quarter of section 1 (3 N., 2 W.), Cotton Township. Rock is obtainable in considerable quantities on this farm.

Around Quercus Grove the limestone is near the surface. A cistern dug about one mile southeast of the village penetrated rock at a depth of eight feet. It is thus seen that even in this most level part of the county the rock is not too far below the surface for quarrying.

From Quercus Grove to Patriot there are some parts of the road where the pike has been made on one side of the highway, space having been left for a dirt road. This arrangement is not conducive to the maintenance of the best conditions on the pike, since the loose clay of the road is much washed from the hillsides down upon the pike in its lower parts. A covering of mud two to six inches deep is thus frequently found upon these lower parts after every hard rain.

Samuel Locke.—Part of the southeast quarter of section 14 (2 N., 3 W.), Jefferson Township. A sample was taken from the hillside on this lot in the rear of Vevay and tested at the Road Laboratory at Washington, D. C. It is practically the same kind as is obtainable in all parts of the county. The results of the physical tests were as follows:

*Results of Physical Tests of Ordovician Limestone from land of Samuel Locke, Vevay, Switzerland County.**

Specific gravity	2.7	French coefficient of wear	7.5
Weight per cu. ft. (lbs.)	168.4	Hardness	4
Water absorbed per cu. ft. (lbs.)	.57	Toughness	8
Per cent. of wear	5.4	Cementing value—Dry	25
		Wet	46

"Somewhat above the average in hardness for limestone, but below in toughness and resistance to wear; cementing value good. Best suited for light highway and country-road traffic."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Ordovician Limestone from land of Samuel Locke, Vevay, Switzerland County.

	Per cent.
Alumina (Al_2O_3)	.33
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	54.50
Magnesia (MgO)	Trace
Phosphoric acid (P_2O_5)	.62
Insoluble in hydrochloric acid	2.28
Loss on ignition	42.14
Total	100.12

*For standard of comparison see p. 79.

JEFFERSON COUNTY.

Area in square miles	362
Population in 1900	22,913
Miles of public road	790
Miles of improved road	107.3*
Percentage of roads improved	13.6
Miles improved with gravel	None
Miles improved with crushed stone	107.3
Average original cost per mile of toll roads purchased	$2,075
Average original cost per mile of stone roads built	$1,282
Total original cost of improved roads	$177,363
Annual cost of repairs per mile on stone roads 5 years old	$50
Miles of improved roads built in 1905	None
Miles of improved roads contracted for 1906	None
First free improved roads built	1897
Satisfaction of farmers with investment in improved roads	Good
Authority	G. F. Crozier, County Auditor

*Of these, 54.71 miles were formerly toll roads which have been purchased by the county, while 52.62 miles have been built under the present laws.

The greater part of Jefferson County has rock easily accessible for road making, while the gravel is confined mainly to the terraces on the Ohio River. From the southwest part of Switzerland County a broad gravel terrace enters this county and extends as far as the town of Brooksburg. Many of the streams have more or less coarse limestone gravel, 1 inch to 6 or 8 inches in diameter. This has been used to a considerable extent, but crushed rock is now coming to be generally used for pike building. There is a very small amount of flint and iron oxide gravel washed up by the freshets on the small streams in the northern and western parts of the county. It comes from the soil covering this region. This makes a good top dressing for roads, but since it is so limited in amount it is not to be depended upon, except for some slight repairs where it can be conveniently used. The flinty gravel does not pack and is unusually hard for horses' feet. No definite location of these gravel beds is practicable, but many creeks in Lancaster Township have beds of gravel from 5 to 50 square rods in area.

Jefferson County owns no stone crushers, nor are any owned by any township therein. Several crushers are owned by private parties. Much of the rock used on pikes is broken by hand. Several old toll roads have been bought by the county. Madison

Township has more pikes than any other township in the county, since most of the pikes in the county lead to Madison. There are many poor roads, but the prospects are encouraging for greater improvement.

S. F. Lamb.—Section 21 (3 N., 12 E.), Craig Township, Switzerland County. A small stream coming from the highlands of Switzerland County cuts the high terrace in the southwest corner of that county and enters the Ohio River about half a mile east of the boundary between the counties of Switzerland and Jefferson. On the banks of this stream gravel is exposed in several places for about a mile. Some has been used from this farm.

J. A. Phillips.—Northeast quarter of section 21 (3 N., 12 E.), Craig Township, Switzerland County. This adjoins the Lamb farm and has gravel of the same kind as is there found. Some of the gravel from these farms has been used on the road between Lamb and Brooksburg. It does not pack well since there is much sand contained therein.

The road from Lamb to Brooksburg lies through a region where gravel and rock are abundant, but it has received very little improvement. For much of the way from Lamb to Brooksburg the river's edge is bordered with gravel, while the terrace is covered with 10 to 20 feet of silt.

On the McHay farm, northeast quarter of section 12 (3 N., 11 E.), Milton Township, about 20 rods south of the mouth of Indian-Kentuck Creek, occurs a prominent exposure of gravel in a terrace about 45 feet high. The top 10 feet is silt, the rest is gravel. This slopes gradually to the river's edge a distance of some 12 rods. The gravel is 1/4 inch to 3 inches in diameter. The amount exposed decreases towards Lamb. Below Brooksburg coarse gravel lines the river edge for about 1½ miles. It is hauled from here to repair roads near Brooksburg.

From the west side of the northwest quarter of section 5 (3 N., 11 E.), to the southeast corner of section 33 (4 N., 11 E.), the river is edged 2 to 10 rods wide with the coarse limestone gravel that has been washed out of the rocky banks. This gravel is used on the streets of Madison, the larger pieces being broken up with hammers as it is applied.

Not much gravel occurs between Brooksburg and Madison.

Some coarse gravel is washed out by swift streams emptying into the Ohio River. At Madison the terrace begins near the east end of town and extends to the mouth of Clifty Creek. The city is built largely on the upper terrace, where gravel comes to within 6 or 7 feet of the surface.

From Madison to Marble Hill several deposits of gravel occur. Many intermittent streams bring down coarse limestone gravel from the neighboring hills. At Hanover Landing there is a strip of gravel extending half a mile or so along the edge of the Ohio River. This has been tried on the hill roads, but is found to be very unserviceable on account of the ease with which it is washed off by the rains.

No gravel occurs from Hanover Landing to Plow Handle Point. In the northwest quarter of section 32 (2 N., 10 E.), Saluda Township, the high terrace begins, rapidly widening to about 40 rods, and extends for about 3 miles at a distance from the river of about ½ mile. Below this the middle terrace extends some 20 rods toward the river. The lowest terrace reaches to the river some 30 rods farther.

Gravel may be found outcropping along the edge of the high terrace. On the F. M. Lee farm a large pit has been opened.

A. D. Harrell.—Southeast quarter of section 7 (2 N., 9 E.), Saluda Township. This farm lies near the south end of the terrace and a small pit has been opened for repairing the road in the vicinity.

From Saluda Creek southward to about 1 mile north of Bethlehem the river keeps near the bluffs and there is no terrace gravel.

The whole length of the river boundary of this county is marked by steep limestone bluffs, some 400 feet high. In order to reach the higher level of country, advantage is taken of the little valleys which cut through to the river level. In some places the wagon road has been cut along the face of the bluffs, rising with a slope of 16 to 24 inches to the rod.

The Madison-Hanover pike, seven miles long, has a very easy ascent to the top of the bluffs, and the roadway is very smooth. This pike has been in use for some 40 years, and a great amount of travel passes over it. It is in very good condition.

Stephen Lewis.—South half of the southwest quarter of section

13 (3 N., 9 E.), Hanover Township. Here is a limestone quarry about 1 mile south of Hanover, near the roadside. Two miles of pike were built from this quarry five years ago. The pike was built largely from a soft sandy limestone layer found near the top. The material is so soft that it easily grinds up into dust and sand. When wet, this forms a layer 2 to 3 inches thick of mortar-like mud. Other layers of this quarry are of a hard, fine-grained rock that would furnish a road metal far superior to the kind used.

Section on land of Stephen Lewis.

	Feet.	Inches.
1. Soil	3 to 8	..
2. Limestone in 3 to 12-inch layers, firm, hard, containing crystals of calcite thinly scattered throughout	5	..
3. Limestone, similar to the above except containing some sand	....	6
4. Limestone in 6 to 24-inch layers, buff colored, very sandy	9	..
5. Limestone, thick-bedded in 2 to 24-inch layers, grayish blue in color, a little sandy	6	..

No. 2 of the section contains few fossils and at the junction of this stratum with the next lower has the peculiar dove-tail structure sometimes noticed. Stratum No. 4 contains intervening layers largely made up of chert nodules, which extend also into the layers of limestone. The limestone contains crystals of calcite, varies much in texture, some layers being soft enough to pulverize easily, some being very firm. The few fossils are mainly corals. The upper layers of stratum No. 5 contain some chert. Some of the layers are separated by the rough dove-tail structure, the fracture frequently showing a peculiar pearly lustre.

Samples of rock from this deposit were secured and sent to Washington, D. C., for testing in the U. S. Road Laboratory. The results of the physical tests were as follows:

*Results of Physical Tests of Devonian Limestone from Land of Stephen Lewis, Hanover, Jefferson County.**

Specific gravity	2.5	French coefficient of wear	3.2
Weight per cu. ft. (lbs.)	159	Hardness	—16
Water absorbed per cu. ft. (lbs.)	3.58	Toughness	7
Per cent. of wear	12.3	Cementing value—Dry	23
		Wet	42

"A very soft limestone, below the average in toughness and very low in resistance to wear; cementing value good. Best suited for country-road traffic."—Page.

*For standard of comparison see p. 79.

A chemical analysis of the samples, made at the same laboratory, resulted as follows:

Chemical Analysis of Devonian Limestone from Land of Stephen Lewis, Hanover, Jefferson County.

	Per cent.
Alumina (Al_2O_3)	.59
Iron oxide (Fe_2O_3)	.51
Lime (CaO)	30.00
Magnesia (MgO)	19.15
Phosphoric acid (P_2O_5)	Trace
Insoluble in hydrochloric acid	5.13
Loss on ignition	44.37
Total	99.75

Saluda Township had no pike up to the year 1905, but in the fall of this year 26 miles were voted to be constructed, some of the strongest opponents several years ago being now the most enthusiastic in favor of the proposition. While most of the township is easily supplied with rock, there are some parts little cut by valleys, and here the rock lies at 10 to 30 feet below the surface.

Andrew Berry.—Southeast quarter of section 8 (2 N., 9 E.), Saluda Township. Where a small ravine crosses the road just west of this farm house there is an outcrop of black shale, under which is a sandy limestone. This stone crops out at several places along the road as far north as Edward Berry's place. Several acres lie with only a few inches of soil on top of the rock. Limestone caves are frequent in the vicinity. On the Hines Hardy farm, southwest quarter of section 8 (2 N., 9 E.), there is also rock existing under similar conditions.

On a small creek north of the Berry place sandy limestone crops out 9 to 15 feet above the creek bed. Below this is about two feet of very firm limestone, then six or seven feet of friable limestone, with numerous fossils. Between this place and the Corie farm several outcrops of black shale appear along the road.

James Corie.—Southwest quarter of section 20 (3 N., 9 E.), Republican Township. Limestone outcrops in a small run by the road about 40 rods north of the north line of Saluda Township. Shale lies above and crops out on the hillside.

In the southeast corner of the northwest quarter of section 20

(3 N., 9 E.), Republican Township, where the Swanville-Hanover pike crosses a small creek, limestone crops out in the creek bed and for 15 feet above. The stone is similar to the Hotchkiss sample. The sandy layer does not here appear beneath the shale. Five to ten acres along this valley could be obtained with not more than four feet of stripping, while much lies uncovered.

Henry Hensler.—Part of the southeast quarter of section 32 (4 N., 9 E.), Republican Township. About six miles of pike east and west of Kent were made from a quarry opened on the banks of Little Creek, 20 rods north of Kent. This is a sandy limestone ledge 16 feet high, underlain by fine-grained limestone. No shale appears. There is about two feet of soil on top. The pike was made from the softer sandy layer. The surface of the road is moderately even, but has a considerable amount of pulverized material on top.

The west end of the Kent pike was built of crushed rock and covered with creek gravel. This has a smooth top with little dust. Rock for this part of the Kent pike came partly from Pleak's quarry and partly from Davis's quarry. It is a fine-grained, hard limestone, and makes a fine road.

Robert Dunlap.—Southeast quarter of section 35 (4 N., 9 E.), Madison Township. Rock outcrops on Ramsey Creek, which here crosses the pike. The rock is so situated as to be easily quarried. From here down to Big Creek rock may be found along the stream.

J. B. Milligan.—Northeast quarter of section 16 (3 N., 9 E.), Hanover Township. Limestone crops out by the road. Rock was obtained here for two miles of pike. It is a shaly, fossiliferous limestone above, and a hard gray limestone below. Two or three acres would be available with considerable stripping.

J. A. Slider.—Northwest quarter of section 16 (3 N., 9 E.), Hanover Township. A limestone cliff 20 feet above the creek bed has been used to repair roads in the vicinity. The rock is a dark gray, hard, fossiliferous limestone. Several acres would be available with one to four feet of stripping. Rock from this neighborhood was used on the pike running south from the Hanover-Swanville pike. It is wearing only fairly well, being easily crushed into dust. It was built four years ago.

The Hanover-Swanville pike was built of creek gravel. It has been made 40 years. There being no rock bottom, the road is easily cut through in times of much rain or when frost is coming out.

In the western part of Graham Township limestone is rather difficult to secure and the black shale is used to some extent. Twenty-six miles of pike are to be built in this township, and for its entire length rock can be obtained within a distance of one mile.

The road from North Madison to Wirt is made of creek gravel, and, in some places, of gravel over broken stone. It wears up to one or two inches of loose material in a dry time, and is not a smooth road to travel.

In sections 16, 17, 20, 21 (4 N., 10 E.), Madison Township, and other places in the vicinity, where branches of Clifty Creek reach back into the level upland, limestone can usually be discovered in the creek beds.

On Herbert's Creek, where the Deputy pike crosses, there is a rock outcrop. Gravel is washed up in the bed of the creek into bars containing 25 to 500 square yards. This gravel consists of limestone 50 per cent., in pieces three to six inches in diameter, and 50 per cent. chert and limestone, one-half to two inches in diameter. From Clifty Creek to Herbert's Creek are some places where the flint gravel top dressing is well packed and smooth. This occurs mainly in places where the shade of trees prevents the ground from becoming dried out entirely.

At Wirt, limestone outcrops on the banks of Herbert's Creek, 30 or more feet above the creek bed. Rock underlies the level country here at 10 to 15 feet below the surface. Herbert's Creek, which runs through Wirt, has considerable flint gravel, both in the channel and in a low terrace, just below the wagon bridge.

Joseph Fisher.—West half of the southwest quarter of section 17 (4 N., 9 E.), Smyrna Township. Mr. Fisher has several places on his farm where rock can be conveniently obtained. One of these produces hydraulic limestone. A blue limestone, suitable for pikes, has been used to repair the gravel pikes near by.

Frank Law.—Northeast quarter of section 14 (4 N., 8 E.), Graham Township. On the north side of the road west of Big

Creek, where the road crosses, and about a mile northeast of Graham, there is an outcrop of very hard, fine-grained limestone, in beds one to two feet thick. It is an excellent stone, and has been used for building purposes to some extent.

David Robertson.—Southeast quarter of section 8 (4 N., 8 E.), Graham Township. At the edge of the village of Deputy is a limestone quarry from which rock has been taken for many years. It is located in the bank of Lewis Creek, and the rock rises to 20 feet above the creek bed. It is a hard, gray-blue, fine-grained limestone, containing few fossils. Ten to 20 acres are available with one to three feet of stripping. The face of the quarry is about ten feet high. The layer from which the sample was taken is about four feet thick. Other layers are not quite so hard. Samples from the quarry were tested in the U. S. Road Laboratory with the following results:

*Results of Physical Tests of Devonian Limestone from land of David Robertson, Deputy, Jefferson County.**

Specific gravity	2.7	French coefficient of wear	8.5
Weight per cu. ft. (lbs.)	168.4	Hardness	—.3
Water absorbed per cu. ft. (lbs.)	.43	Toughness	7
Per cent. of wear	4.7	Cementing value—Dry	53
		Wet	81

"A rather soft limestone and below the average in toughness; about the average in resistance to wear, with good cementing value. Best suited to country-road traffic."—Page.

A chemical analysis of the sample was made at the same laboratory, which resulted as follows:

Chemical Analysis of Devonian Limestone from the land of David Robertson, Deputy, Jefferson County.

	Per cent.
Alumina (Al_2O_3)	1.40
Iron oxide (Fe_2O_3)	.23
Lime (CaO)	31.90
Magnesia (MgO)	15.18
Phosphoric acid (P_2O_5)	.25
Insoluble in hydrochloric acid	7.88
Loss on ignition	42.75
Total	99.59

*For standard of comparison see p. 79.

The pike from North Madison to Deputy is mainly of flint gravel. On Mr. Joseph Fisher's place are gravel bars in Big Creek, comprising 800 to 1,000 loads. The gravel is one-fourth to two inches in diameter.

Lancaster Township is well supplied with rock, which can be obtained on Big Creek and all its branches. In the northeast part of the township there are two or three sections without exposure of rock.

Section at Lancaster Flour Mills, south half of southeast quarter of section 33 (5 N., 9 E.), Lancaster Township.

	Feet.	Inches.
1. Limestone brownish-gray, hard, fine-grained, weathering or disintegrating into cavernous structure	12 to 14	..
2. Limestone blue-gray, hard, fine-grained, somewhat thin bedded (3 to 12 inches)	8	..
3. Limestone, light gray, without chert, but otherwise like No. 2	2	6
4. Limestone, variegated, greenish-yellowish, grayish, pearly lustre on fresh fracture, fine-grained	5	..

Strata Nos. 2 and 3 are more easily eroded, so that the massive bed above forms an overhanging cliff. Stratum No. 2 contains much chert arranged in layers more or less regularly between the layers of limestone, sometimes embedded in a layer of limestone, sometimes forming a distinct layer by itself, one to two inches thick. The layer two feet from the bottom is about three inches thick and is very persistent along the exposure.

No. 4 is harder than No. 3, somewhat shaly in arrangement and fracture, slightly arenaceous.

The above section gives the lower 30 feet of the rock through which Big Creek cuts. In many places the cherty upper layer has disintegrated, leaving a brownish red soil, containing many cherty fragments, which, being washed out by rains, are collected in the stream channels.

From Lancaster to Wirt rock is found in the valleys of al. the streams.

Along the north line of the county from the middle of section 6 (5 N., 10 E.), to the middle of section 3 (5 N., 9 E.), rock is exposed.

Monroe Township has rock in abundance along all the larger streams. Big Creek forms a gorge-like valley with rocky sides rising 30 to 40 feet above the creek bed. Also in the branches of Middle Fork and of West Fork of Indian-Kentuck Creek, rock is available. On the divide between these streams the soil lies at a depth too great for quarrying, but rock on any of the creek branches may be found within easy hauling distance.

James Denny.—Northwest quarter of section 23 (5 N., 10 E.), Monroe Township. About half a mile north of Belleview school house and church a little run crosses the road. Here rock is exposed, while on top of the hill where the house stands rock is within eight feet of the surface.

The Michigan road runs in a northerly direction from Madison towards Bryantsburg, ten miles. It has been built forty years or more and is made of broken stone, obtained largely from Indian-Kentuck Creek. The road lies along the divide between Indian-Kentuck and Big creeks. Throughout its length rock is not exposed at the surface for a distance of a mile or more on each side. Part of the way it is topped with flint gravel. The surface is moderately smooth and solid, but is not kept in very good repair.

From Brooksburg to Manville along Indian-Kentuck Creek for about two miles the road is to some extent bedded with broken rock, but it is a very rough road, as the rock is applied too thinly and in too large pieces. The rest of the way it has little or no improvement. There is some gravel in this creek. A bar appears in the southwestern quarter of section 24 (4 N., 11 E.), comprising half an acre two feet deep. This gravel is a mixture of fine and coarse limestone and flint, varying from one-fourth to five inches in diameter. Some has been used on the road nearby, and it makes a solid bed with smooth surface.

Lucy Sinkhorn.—Northeast quarter of section 22 (4 N., 11 E.), Milton Township. Gravel appears on the bank of the Indian-Kentuck Creek by the side of the road. There is about four feet of silt on top. The gravel is moderately coarse, being one to two inches in diameter, with some soil intermingled.

At Manville there is much gravel in the creeks just above the bridges, in all probability an acre, one to two feet deep. It varies in size from sand to boulders three to six inches in diameter,

but is mostly of one to three inches in diameter. It is made up largely of limestone. This is used on roads in the vicinity and makes a good surface. Farther up the streams the gravel becomes coarser and more abundant.

A large area south of Canaan is high level country and the roads are unimproved. Rock would have to be hauled two to three miles for some of the roads. Other parts of Shelby Township lie within easier access to limestone outcrops.

The Canaan-Madison pike, eight miles long, has been built eight years. It is made of broken stone and topped with creek gravel. This gravel, largely of limestone with some flint, forms a smooth, hard surface, that does not easily wear into dust.

Agnes Vaughan.—Northwest quarter of section 28 (4 N., 10 E.), Madison Township. Limestone crops out at the head of a small valley near the house. This level is probably 30 feet lower than the railway station at North Madison, and is the nearest outcrop on a direct west line from North Madison. This is a firm, gray limestone. About 30 feet lower, farther down the valley, is another outcrop. This is of a somewhat sandy limestone, which resembles one of the strata at the Lewis quarry.

Richard Johnson.—Northwest quarter of section 28 (4 N., 10 E.), Madison Township. The sample was obtained from a hard, fine-grained, thin-bedded layer, forming the upper ledge of a small waterfall in a branch of Clifty Creek. Below this layer were about eight feet of soft clay and clayey limestone. This is probably the lower part of the Niagara formation. Several acres would be available with little or no stripping. None has been used for roads.

Samples were tested at the U. S. Road Laboratory with the following results:

Results of Physical Tests of Niagara Limestone from the land of Richard Johnson, North Madison, Jefferson County.

Specific gravity.................	2.6	French coefficient of wear.	7.8
Weight per cu. ft..........(lbs.)	165.3	Hardness.................	3
Water absorbed per cu. ft..(lbs.)	3.21	Toughness................	12
Per cent. of wear..............	5.2	Cementing value—Dry....	36
		Wet....	53

"Slightly above the average in hardness for limestone, and fairly tough; rather low in resistance to wear, and fairly good cementing value. Best suited for light highway and country-road traffic."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Niagara Limestone from Land of Richard Johnson, North Madison, Jefferson County.

	Per cent.
Alumina (Al_2O_3)	1.14
Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	52.00
Magnesia (MgO)	2.30
Phosphoric acid (P_2O_5)	.16
Insoluble in hydrochloric acid	1.77
Loss on ignition	42.40
Total	99.77

JENNINGS COUNTY.

Area in square miles	380
Population in 1900	15,757
Miles of public roads	621
Miles of improved roads	218
Percentage of roads improved	35.1
Miles improved with gravel	6
Miles improved with crushed stone	212
Average original cost of gravel roads per mile	$1,348
Average original cost of stone roads per mile	$1,975
Total original cost of improved roads	$426,788
Annual cost of repairs per mile on gravel roads 5 years old	$25
Annual cost of repairs per mile on stone roads 5 years old	$30
Miles of improved road (stone) built in 1905	14
Miles of improved road (stone) contracted for 1906	7
First improved roads built	1896
Proportion of improved roads built since 1895 (per cent.)	100
Satisfaction of farmers with investment in improved roads	Good
Authority	W. S. Campbell, County Auditor

Except for about three miles of the west side of Jennings County, it is well supplied with limestone. Some gravel is used to repair roads, but it is not considered desirable for permanent and exclusive use. In most townships the aim is to use crushed rock. There are no gravel banks. All the gravel that occurs is found as bars in streams. It is flinty and sandy and is not good road metal.

This county is one of the most advanced in the improvement of roads. While for some parts rock must be hauled three or four miles, the roads have not been neglected on that account. Roads

are built by contractors. A few townships own crushers. Both white and "blue" limestones are used. Some sandy limestone has been placed on one road southwest of Vernon.

About one mile east of Grayford limestone outcrops in a small run by the road. The limestone is a firm, gray and cavernous stone, about five acres of which are available. Black shale outcrops on top of a hill 40 rods east of Grayford.

The pike running from Vernon to the Ripley County line by way of San Jacinto was built seven years ago. The two miles next to Vernon are mainly of gravel. The rest is rock. Two miles of pike east of Grayford is in poor condition, owing to excessive wash by rains. The side ditches have washed back into the road, so that the rock is falling out. In some places the soil has washed down and covered the lower parts of the road, making much mud in a wet time. Farther east, where the country is not so hilly, the pike has not washed so badly. This road was not graded enough before the rock was applied and there is little if any slope to the surface. The rock used here makes a smooth, hard surface, with little dust. That for the east end of this pike was obtained from the Henry Stanley farm. For one-half mile or so north of San Jacinto the pike has been topped with flint gravel. It here has a smooth, solid, even surface.

Henry Stanley.—Northwest quarter of section 23 (6 N., 9 E.), Bigger Township. A quarry is located on the bank of Graham Creek, just east of the bridge near San Jacinto. There is a 12 to 14-foot face of rock, which is a hard, gray-colored, fine-grained limestone, containing some chert nodules in layers one to three inches thick. Some 30 acres of surface are yet available. It is a very good road metal, and about seven miles of pike have been made from this quarry.

About 100 rods north of Daniel Walker's farm house, southeast quarter of section 24 (6 N., 8 E.), Vernon Township, limestone outcrops at the base of the black shale in a little valley crossing the road. The shale is not over 25 feet thick, and from its top to the level of the upland is about the same distance.

E. B. O. Lamb.—Southwest quarter of section 31 (6 N., 9 E.), Vernon Township. Limestone crops out of the ground six to eight feet above the bottom of a small valley, about two miles west of the P., C., C. & St. L. Railway crossing.

Alice Deputy.—Southwest quarter of section 3 (5 N., 8 E.), Lovett Township. A small valley about 20 rods west of the road has rock exposed on its sides. Several acres could be obtained with little stripping. The pike here is comparatively new. Not all the rock has yet been thoroughly packed. The surface, for the most part, is hard and smooth.

The whole length of Graham Fork lies in a valley cut into limestone, while outcrops may be found in the tributary valleys one to two miles away from that stream. Near Comiskey, black shale is within eight or ten feet of the surface.

From Comiskey to the west line of Jennings County runs a rock pike, built about four years ago. It is an unusually well-made pike. The road is well graded and the surface is very hard, smooth and even. It runs over a generally level upland for much of the way. The first mile or so west of Comiskey is hilly.

John A. Liddle.—Southwest quarter section 14 (5 N., 7 E.), Marion Township. Part of the rock for the 13 miles of pike in Marion Township was obtained from here. The quarry is located in a valley and the outcrop is about the westernmost limit of the Devonian limestone in this part of the county.

Valentine Gruber.—West half of the southwest quarter of section 14 (5 N., 7 E.), Marion Township. About 20 rods west of Liddle's quarry and lower down the valley another opening was made for rock for these pikes.

Section of Liddle's and Gruber's Quarries.

		Feet.
1.	Soil	6
2.	Shale, black to brown	3
3.	Limestone, tough, gray, fine grained, not many fossils	3
4.	Limestone, light gray and more brittle, containing a good many fossils	6
5.	Limestone blue, clayey, fine-grained, non-fossiliferous (hydraulic).	2+

Rock crops out on the road just north of Tea Creek, southeast quarter of section 11 (5 N., 7 E.), Marion Township.

T. Wiley Child.—Northeast quarter of section 35 (6 N., 7 E.), Lovett Township. In a small valley opening into Muscatatuck River limestone outcrops and a quarry has been opened. About three miles of pike in Spencer Township were built from this quarry. Rock is now being secured for two miles of pike in

Lovett Township. The crusher is owned by private parties. The rock is a hard, fine-grained, gray limestone, with few fossils. About two acres would be available with three to four feet stripping.

No rock is exposed in the bed of the Muscatatuck River at the south line of Spencer Township.

Hayden pike, south of Belleview church, is in poor condition. The wheels have cut through the stone to some extent on the bottom land, leaving ruts and uneven places. North of Belleview the pike is in better condition. There is no outcrop of limestone from the Muscatatuck River to Hayden. At Hayden shale crops out in the road south of the schoolhouse.

Wm. S. Baker.—Northwest quarter of the northwest quarter of section 4 (6 N., 7 E.), Spencer Township. This is the western limit of Devonian limestone in Spencer Township. Limestone is found in the bottom of a valley about two miles northwest of Hayden. Several quarries have been opened in this valley. About one mile of pike has been built from the quarry last opened. From three to four feet of soil lies on top. The top layer of rock is the same as the last two or three feet of the second stratum in Liddle's quarry. Below this comes a two-foot layer of blue hydraulic limestone, followed by four to six feet of grayish-blue limestone, somewhat fossiliferous and not so fine-grained as the layers above.

Mr. Baker has constructed most of the pikes in this part of the county. He is now building two miles of pike in the western part of Spencer Township. This limestone makes a smooth pike. The new pike is built of rock crushed to the size of about two inches in diameter and is topped with screenings. Samples from this quarry were tested in the U. S. Road Laboratory, the results being as follows:

Results of Physical Tests of Devonian Limestone from land of Wm. S. Baker, Spencer Township, Jennings County.

Specific gravity	2.7	French coefficient of wear	12.6
Weight per cu. ft. (lbs.)	168.4	Hardness	8.5
Water absorbed per cu. ft. (lbs.)	.93	Toughness	9
Per cent. of wear	3.2	Cementing value—Dry	49
		Wet	97

"A fairly tough rock with a good resistance to wear and an excellent cementing value. A good all-around road material."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Devonian Limestone from land of Wm. S. Baker, Spencer Township, Jennings County.

	Per cent.
Alumina (Al_2O_3)	.18
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	47.80
Magnesia (MgO)	3.44
Phosphoric acid (P_2O_5)	.52
Insoluble in hydrochloric acid	6.40
Loss on ignition	41.04
Total	99.63

Limestone forms the bed of Six-Mile Creek at the bridge, east of Hayden. From 10 to 15 feet of black shale is exposed above.

Where the road crosses Indian Creek, northeast quarter of section 7 (6 N., 8 E.), Vernon Township, limestone crops out three to four feet above the creek bed. Five acres or more would be available.

The Hayden-North Vernon pike is much out of repair, being much worn by traffic and by rains. Some attempt is being made to repair the worst places.

The road running northeast from Vernon to Butlersville has lately been graveled for two and a half miles, and had not settled sufficiently for good travel.

The pike running west from Butlersville is quite smooth and altogether a good road. It has been in use about five years.

Rock occurs on the farms of Phillips Bros., southwest quarter of section 26 (7 N., 9 E.), Campbell Township, and of J. H. Grimstead, northeast quarter of the northwest quarter of section 19 (7 N., 10 E.), Campbell Township.

O. P. M. Brougher.—Northwest quarter of section 21 (7 N., 9 E.), Campbell Township. Rock for the pike west of Butlersville was obtained from this farm on Pleasant Run, the section being as follows:

Section on farm of O. P. Brougher.

		Feet.
1.	Soil	4
2.	Sandstone, friable, easily weathering into an irregular surface	5
3.	Limestone, hard, gray	1
4.	Limestone, sandy, thin-bedded and containing much chert, either in layers or scattered nodules	6
5.	Limestone, gray, sandy, fine-grained, containing some crystals of calcite. Bottom level with creek bed	4

Rock for a pike running about two miles north of Butlersville was obtained from here. This pike is moderately smooth and even. It has been built five years. The north end is now being repaired with stone from William Price's place south of Brush Creek.

The stone for the pike running south from Butlersville and east to Ripley County came from the Mary Page farm, northwest quarter of section 35 (7 N., 9 E.), Campbell Township. Rock for the west end of the Butlersville-North Vernon pike came from the Gamon quarry, northwest quarter of section 35 (7 N., 8 E.), Center Township. The pike running south from Butlersville is in fair condition, though it is moderately dusty and needs repairs.

Gravel is quite plentiful in Campbell Township, on North Fork and its branches. On the hill between Brush Creek and North Fork there is a small accumulation of cherty gravel. On the north side of North Fork, about 25 feet above the creek bed, where the road cuts through the hillside, there is a deposit of coarse gravel, mostly chert, arranged in such a way as to suggest deposition by water. It is 2 to 3 feet thick, running in a horizontal direction. From 5 to 6 feet of yellow soil lies on top. The gravel is in size from 1/4 of an inch to 3 inches in diameter and is mixed with some sand.

William Morris.—Part of the east half of the southeast quarter of section 16 (8 N., 9 E.), Columbia Township. A quarry was opened up here and rock was taken out for about a mile of the new pike running north from the Zenas-North Vernon pike, 2 miles east of the west line of Columbia Township. The rock here proving to be inaccessible in sufficient amount, the crusher was removed to William Blowbell's farm in the edge of Decatur County. The rock taken from the Morris farm was a moderately hard limestone, containing some sand. The opening of the quarry on the Blowbell farm was attended with some dissatisfaction on the part of the road superintendent, because the stone there being quarried was merely a sandstone, which pulverized easily in the process of crushing and did not appear to be suitable for road purposes. This quarry was visited by the writer, and the attitude of the road superintendent seemed easily justifiable. The

rock section showed about 10 feet of sandstone, much decomposed on the surface, with about 4 feet of sandy limestone below. On a fresh fracture the sandstone presents a tolerably hard texture, but there is much loose sand coming from the crushing process. Had the quarry been opened in the creek bed it is likely that a good limestone could have been obtained.

Thomas Woods.—Northwest quarter of section 25 (8 N., 9 E.), Columbia Township. There is here a limestone quarry from which rock was obtained for pikes west and south of Zenas.

Section of quarry of Thomas Woods, Columbia Township, Jennings County.

		Feet.
1.	Soil	4
2.	Disintegrated limestone containing chert	2 to 3
3.	Limestone, gray, fine-grained, hard, somewhat arenaceous, in beds of 6 to 18 inches	6

Rock outcrops on the hill east of Zenas, about 50 feet above the creek. The creek bed is in rock, but is partly covered with a limited amount of cherty gravel. There also occurs on the hillside a deposit of cherty gravel, which seems to be the result of disintegrated limestone. The pike toward Nebraska is in a fairly good condition with some loose material on the surface.

J. R. Hazen.—West half of the northeast quarter of section 30 (8 N., 9 E.) Sand Creek Township. Limestone was taken from here for the pike near by.

C. A. Jackson.—Northwest quarter of section 32 (8 N., 9 E.), Columbia Township. From this farm on Little Bear Creek rock was obtained for part of the Zenas-North Vernon pike. The rock is a soft white, fine-grained, clayey limestone. On the road it grinds up considerably, but does not form a very loose surface. It is said to cut through in spring time.

J. A. Miller.—Northwest quarter of section 1 (7 N., 8 E.), Sand Creek Township. From this quarry rock was obtained for part of the Zenas-North Vernon pike.

Section of quarry of J. A. Miller.

		Feet.
1.	Soil lying on a much eroded surface of limestone	3
2.	Limestone, white, fine-grained, soft, containing considerable clay. Upper 2 to 3 feet containing much calcite	12

This rock is only fairly good for roads, it being so soft as to grind up easily under traffic.

In the central part of Columbia Township rock is not easily obtained as it lies deep (20 to 40 feet) below the surface. But all along the North Fork of the Muscatatuck River rock occurs close to the surface; also on Little Bear Creek near the west line of the township. In the northwest part of the county the soil is sandy and the valleys have much sand deposited in them.

I. B. Stearns.—Part of the northeast quarter of section 3 (7 N., 8 E.), Sand Creek Township. This farm borders Sand Creek for half a mile or more. The creek has high banks with outcrops of limestone in which, as yet, no quarry has been opened. The rock is a tough, fine-grained, bluish-colored limestone, in layers 3 to 12 inches in thickness. About 100 acres are available. Samples were sent to Washington for testing in the U. S. Road Laboratory, with the following results:

*Results of Physical Tests of Devonian Limestone from land of I. B. Stearns, Sand Creek Township, Jennings County.**

Specific gravity.................	2.7	French coefficient of wear.	10.9
Weight per cu. ft..........(lbs.)	168	Hardness................	6.3
Water absorbed per cu. ft..(lbs.)	.57	Toughness................	8
Per cent. of wear..............	3.7	Cementing value—Dry....	28
		Wet....	94

"A rock of fair hardness, toughness and resistance to wear and good cementing value. Suitable for highway and suburban traffic."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Devonian Limestone from land of I. B. Stearns, Sand Creek Township, Jennings County.

	Per cent.
Alumina (Al_2O_3)	.41
Iron oxide (Fe_2O_3)	.24
Lime (CaO)	46.35
Magnesia (MgO)	5.67
Insoluble in hydrochloric acid..................................	5.00
Loss on ignition	42.71
Total	100.38

A. N. Robinson.—Part of the southwest quarter of section 2 (7 N., 8 E.), Sand Creek Township. A quarry was opened on the east bank of Sand Creek for building the pike running a mile and a half each way, north and south, through Brewersville.

*For standard of comparison see p. 79.

Road built of this rock has a moderately good surface. Five acres are easily available.

Section of quarry of A. N. Robinson.

		Feet.
1.	Soil	3 to 4
2.	Limestone, yellowish-gray, sandy	1 to 2
3.	Hard clay, bluish-yellow or buff on exposures, pale gray-blue on fresh fracture. Breaks readily into rectangular pieces	5
4.	Limestone, bluish-gray, fine-grained, tough, containing few fossils	2
5.	Limestone, gray, fine-grained, tough, thick-bedded; the lower four feet in some places with numerous chert nodules	5

Stratum No. 3 is probably correlative with the soft limestone of the Miller and the Jackson quarries. No. 4 is similar to the sample tested from the I. B. Stearns place. The bottom of No. 5 is about 12 feet above the creek bed.

O. E. Coryell.—Southwest quarter of section 34 (8 N., 8 E.), Sand Creek Township. Mr. Coryell is just opening a quarry on the north bank of Sand Creek about a mile west of Brewersville. The rock is similar to that on the Stearns farm adjoining. Ten acres could be quarried with the removal of one to eight feet of soil.

The road from Brewersville west to the township line is unimproved, lying over a hilly, timbered country.

The Queensville pike begins about one-half mile west of Pleasant View church near Wyaloosing Creek. This part of the pike is not traveled enough to settle the rock into a smooth surface. The loose pieces have been so much worn by traffic that they have become rounded. This road shows the effects of leaving a pike of crushed rock without a top coating of fine material and without rolling. It has been built five years.

William Byron.—Part of the northeast quarter of section 32 (8 N., 8 E.), Geneva Township. Rock for the north end of the Queensville pike (two miles) was taken from the east bank of Wyaloosing Creek, on this farm.

Section from farm of William Byron.

		Feet.
1.	Soil, containing chert	5
2.	Limestone, blue-gray, fine-grained, massive, cracking on exposure. Few if any fossils	2
3.	Limestone, dark gray, finely crystalline, tough, thick-bedded, few fossils	6
4.	Limestone, bluish-gray, fine-grained, containing some chert	1

The bottom of this layer is about ten feet above the bed of Wyaloosing Creek. Rock outcrops all along this creek.

From Sand Creek to Queensville the road is graveled. This gravel, obtained from creeks, is mainly cherty, varying in size from coarse sand to pieces an inch in diameter. The surface does not pack well, even in damp weather.

From Queensville to Scipio and the county line is a stone pike called the old "State road." Much of the way it has a smooth, firm surface, but where repairs have become necessary creek gravel has been applied and the effect is to make a very poor surface.

Mr. Bennett.—Northwest quarter of section 35 (8 N., 7 E.), Geneva Township. From this quarry rock was obtained for pikes in the vicinity. The rock makes a fairly good road.

Section from Bennett Quarry.

		Feet.
1.	Soil and disintegrated limestone	1 to 3
2.	Limestone, gray, fine-grained, in layers 6 inches to 2 feet thick	8
3.	Limestone, blue-gray, in beds 10 to 12 inches thick	2

The bottom of stratum No. 3 is about 8 feet above the valley bottom of Sand Creek.

Mr. Hutchings.—Part of the northeast quarter of section 2 (7 N., 7 E.), Geneva Township. A limestone quarry northwest of Scipio on the hill near the State road shows the following section:

Section from Hutchings Quarry.

		Feet.	Inches.
1.	Soil	2 to 8	..
2.	Disintegrated limestone	2	..
3.	Limestone, gray, fine-grained, finely striated or banded	12	..
4.	Limestone, dark gray, fine-grained, tough, not showing much of the banded appearance	....	6
5.	Limestone, buff-gray, fine-grained, tough	2	6

Stratum No. 3 is somewhat clayey in nature and has a tendency to fracture at right angles to the bedding plane, with a dove-tail structure between certain layers. No. 4 is separated from the layers above and below by a very rough surface.

Limestone from this quarry has been used on pikes in Geneva Township, about 2,500 cubic yards having been removed. Several acres are here available.

At Scipio, limestone is struck at about seven feet on the level upon which the town is built. From here west, Sand Creek has a wide bottom and no rock exposures except what may outcrop on the hillsides at the edge of the valley.

The pike southeast of Queensville for about three miles is made of a blue-black limestone. The road has not been kept in good repair and is much washed and worn. The North Vernon end of this pike is made of a light colored limestone softer than the blue-black stone used beyond. It has a smoother top than the other part. This rock came from the following quarry near North Vernon:

Pat McGinty.—Northwest quarter of section 34 (7 N., 8 E.), Center Township:

Section of Limestone quarry at the northeast edge of North Vernon.

		Feet.
1.	Soil	6
2.	Limestone, gray, thick-bedded, moderately fine-grained, some layers containing calcite	20
3.	Limestone, gray, banded	6

The bottom is level with the bottom of the ravine where the rock is quarried.

Joseph Smith.—Part of the southeast quarter of section 18 (7 N., 8 E.), Geneva Township. Rock for the pike southeast of Queensville was obtained from this farm.

Geneva Township has plenty of rock in the north and east parts. A portion of the southwest part has little rock exposed and it would be necessary to haul road material three or four miles for some roads. The creek gravel, of which there is a limited amount, is mainly cherty. It is used to repair roads, and several miles of pike are wholly constructed of it. In no case was this gravel found to make a good top for roads, as it will not pack. The rock in this township, being mainly of Hamilton formation, is a tough, grayish limestone, usually thick-bedded. No sandstone occurs and little shale was observed.

Willard New.—Vernon Township. Here is a good outcrop of limestone from which rock was obtained for the pike running south from Vernon.

Section of Limestone on farm of Willard New.

		Feet.	Inches.
1.	Soil	1 to 3	..
2.	Limestone, gray, clayey, in layers 6 to 12 inches thick	4	..
3.	Limestone, blue-black, fossiliferous, hard layers, 1 to 14 inches thick	3	6
4.	Limestone, gray, somewhat crystalline, thick-bedded	2	..

The bottom of stratum No. 4 is about 30 feet above the creek.

The pike running south from Vernon towards Lovett, east of the B. & O. Railway, was built about seven years ago. The north part is not very smooth, but the south end is in very good condition. Much of this part is made of the blue-black limestone which, when firmly compacted, gives a smooth, hard surface.

RIPLEY COUNTY.*

Area in square miles	447
Population in 1900	19,881
Miles of public roads	462
Miles of improved roads	135
Percentage of roads improved	29.2
Miles improved with gravel	15
Miles improved with crushed stone	120
Average original cost of gravel roads per mile*	
Average original cost of stone roads per mile	$2,500
Total original cost of improved roads	$300,000
Annual cost of repairs per mile on gravel roads 5 years old	$75
Annual cost of repairs per mile on stone roads 5 years old	$75
Miles of improved road (stone) built in 1905	18
Miles of improved road (stone) contracted for 1906	26
Miles of improved road built since 1895	100
Satisfaction of farmers with investment in improved roads	Good
Authority	Nicholas Volz, County Auditor

*The 15 miles of gravel road is the abandoned right of way of a railroad turned into a public highway, and cost the county nothing.

Ripley County, with Versailles as its county seat, is in the southeastern portion of the State. It lies beyond the limits of the Wisconsin drift, with its accompanying gravel sheet. The northern half of the county is covered 10 to 25 feet deep with a peculiarly fine-grained compact clay or loess, under which comes very often 1 or 2 feet of blue till. As a rule, between the till and the lower Silurian limestone there is a thin bed of gravel 6 to 10

*The report for this county was written by L. C. Ward.

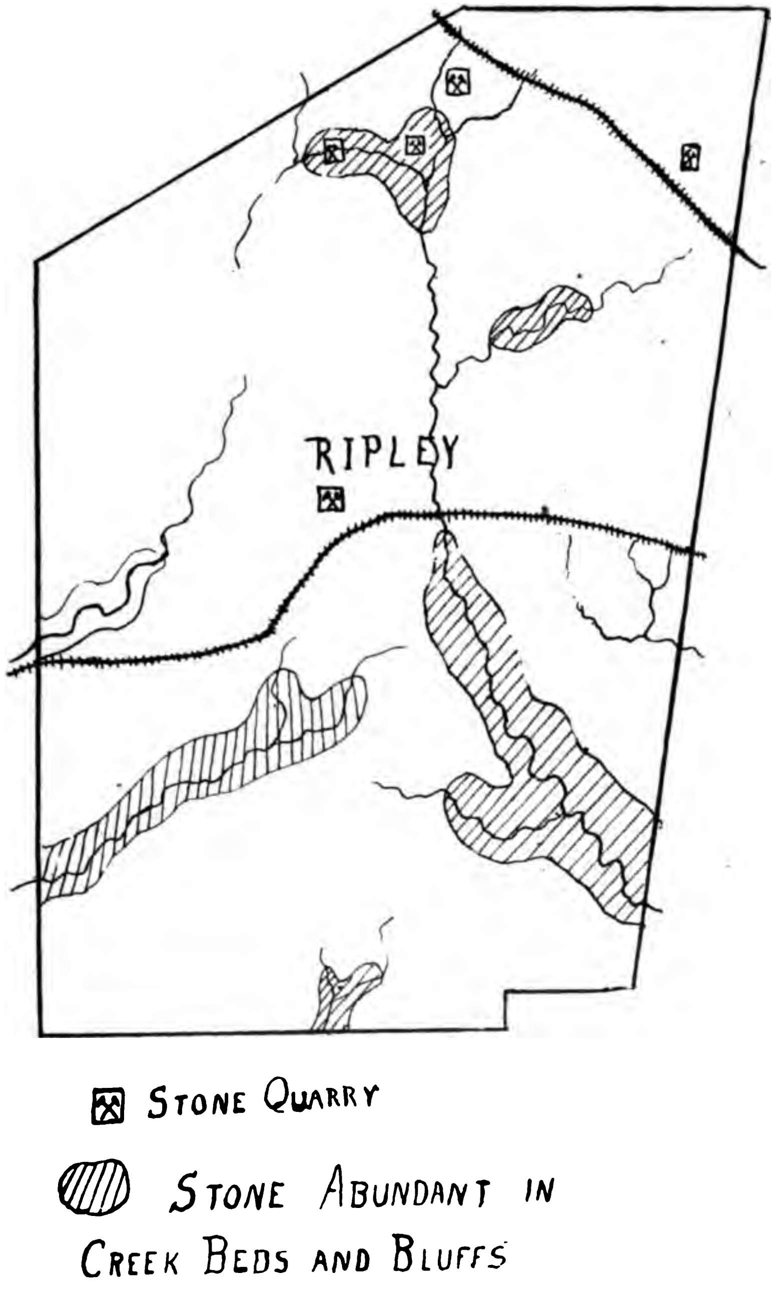

Fig. 49. Illustrating the distribution of road materials in Ripley County.

inches thick. In those portions of the county where the bed rock is Osgood or Niagara limestone, the gravel is usually absent. In the southern portion of the county the yellow clay thins out very much. From Versailles south there are outcrops of stone in many of the fields, and the soil is, instead of the glacial loess, a clay derived from the underlying limestone.

The county is drained by Laughery Creek and its tributaries, Little Laughery, Ripley, and Raccoon creeks and by Little Graham and South Fork, parts of the Muscatatuck system. A small portion of the northeast corner drains into the Whitewater by way of Pipe Creek. Laughery Creek follows pretty closely in its course through Ripley County, the contact between the Cincinnati formation of the Ordovician, and the Niagara of the Silurian. The limestones exposed in the eastern half of the county are therefore Cincinnati; and this is true also of the lowest rocks exposed in the western portion. The upper strata, averaging 12 to 15 feet, are Niagara. It is these latter that are quarried for lime, building purposes and for road purposes. There are three or four quarries in the Ordovician also, but the rock while hard enough when first removed weathers easily unless protected. In the vicinity of Batesville and Ballstown blocks of apparently hard, solid limestone weather in 5 or 6 years to blue mud. At the latter place, and on the Lipps place a mile west of Cross Roads, there is a heavy ledge of rock, underneath this easily weathered ledge, which seems to stand up better. The new stone road from Batesville to Napoleon has been partly built from this ledge. This same rock is exposed in the bed of Laughery Creek on the Shover farm, four miles northeast of Napoleon, and the crushed rock was used on the Napoleon end of the above road.

Between Sunman and Ashton P. O. a small quarry has been opened, and stone gotten out for two miles of road between the two places. This is a fairly hard limestone, very similar to that used upon the Sunman-Milan pike. It makes a good road when care is taken to keep chuck-holes in repair.

In the western portion of the county there are two excellent macadam stones. The Clinton limestone is represented here by a salmon-brown ledge 8 to 24 inches thick, consisting of white siliceous pebbles bound by a limestone cement. It is a hard,

crystalline stone and works well upon the roads. Besides this, there are from 3 to 15 feet of the Laurel and Osgood limestones exposed in most of the streams, and these rocks make very good macadamizing material. The Osgood-Versailles road was piked with this substance many years ago and was a good road with little repair for a long time.

In the southern part of the county there has not been any great effort made toward improving the highways. In this hilly district the roads are pretty well drained and the necessity for a hard surface is not so apparent. These townships, several of them, have a poor soil, and could hardly stand the expense of macadamizing, cheap though that would be.

There is only one considerable stretch of gravel road in the county. The Napoleon-Osgood pike has been built of creek gravel obtained from Otter Creek and Laughery. The roadbed is very narrow, and the owners in the old days were hard put to it to find enough gravel to keep the road in repair. The gravel obtained was from the little bed mentioned above, washed down into the creeks in freshet times.

There are no gravel pits of a workable size in this county. It is too far removed from the ice-front for that; for, according to the law of deposition, the gravel and boulders fall first as the water loses its velocity, then the sand, and finally the clay. Ripley County is in the clay district.

Gradually, as the woods are being removed and farming grows more exact, the people of these poorer counties are beginning to make some money. Houses are better, barns larger, blooded cattle are taking the place of scrubs, and there are signs that the first necessity of modern farming, a good road system, has begun to impress itself upon this county.

DECATUR COUNTY.

Area in square miles	384
Population in 1900	19,518
Miles of public roads	600
Miles of improved roads	175
Percentage of roads improved	29.2
Miles improved with gravel	8
Miles improved with crushed stone	167

Average original cost of gravel roads per mile	$1,500
Average original cost of stone roads per mile	$2,500
Total original cost of improved roads	$420,500
Annual cost of repairs per mile on gravel roads 5 years old	$75
Annual cost of repairs per mile on stone roads 5 years old	$75
Miles of improved roads (stone) built in 1905	11
Miles of improved roads (stone) contracted for 1906	32
First improved roads built	1856
Miles of improved roads built since 1895	110
Satisfaction of farmers with investment in improved roads	Good
Authority	Frank E. Ryan, County Auditor

Decatur County is very well supplied with limestone suitable for pikes, and in some parts there is considerable gravel. Rock is the prevailing material used on roads. Much attention has been given to the improvement of roads in this county.

Chas. T. Robertson.—Northwest quarter of section 20 (11 N., 9 E.), Adams Township. On the left bank of Clifty Creek a little above Adams, a gravel pit has been opened. It is about 100 by 75 yards in area, about 12 feet deep and is overlain with 3 feet of soil. The gravel contains much iron oxide. It is ¼ to 1 inch in diameter, with some of the stones 4 to 6 inches in diameter and with considerable chert.

A strip 30 rods wide and ¾ of a mile long extends along the south side of Clifty Creek to Adams or farther. This gravel deposit forms a high terrace in many places along Clifty Creek in this county and in Bartholomew.

Will Pleak.—South half of section 12 (11 N., 8 E.), Adams Township. On the back part of this farm, where Flat Rock Creek comes against a high bank, there is an exposure of gravel 20 feet thick with a cover of 8 inches of soil. The gravel is ¼ to 1½ inches in diameter and there are a few boulders 4 to 6 inches in diameter.

This has not been used for any but private roads. The deposit is part of a high terrace extending to the southwest a distance of ¾ of a mile with an average width of 40 rods. An old glacial valley, now 30 feet above the bed of Flat Rock Creek, extends southwestward a distance of some 6 miles to the valley of Clifty Creek, just north of Milford. This old valley contains extensive deposits of gravel throughout its length. On the highway west of the Pleak residence is a gravel pit covering some 3,000 square yards. The gravel is ½ to 1 inch in diameter, with many stones

4 to 6 inches in diameter. There are 75 to 80 acres available in this neighborhood.

Henry Porten.—Southwest quarter of the southwest quarter of section 1 (11 N., 8 E.), Adams Township. A small rock quarry has been opened in the bank of Flat Rock Creek near the bridge, about ½ mile south of St. Omer. The location is admirable. A 30-foot face of rock is exposed above the creek. Twenty or more acres could be had with from 5 to 10 feet stripping. Rock crops out all along Flat Rock Creek in Adams Township and is being quarried for building purposes. It is well suited for roads.

Ray Pearce.—Northwest quarter of section 3 (11 N., 8 E.), Adams Township. A gravel pit was opened up here last year. About 2,500 cubic yards of gravel have been taken out. The gravel deposit is 6 feet thick and covered with 2 feet of soil. It is coarse, running from ½ to 1 inch in diameter, and mixed with much fine material, becoming more clayey and sandy as the hill is worked into.

This gravel is located about ¼ mile northeast of St. Paul, on a high terrace 20 feet above Mill Creek, near its junction with Flat Rock. It is probable that further excavation will develop more extensive deposits.

H. C. Adams.—Southwest quarter of section 2 (11 N., 8 E.), Adams Township. There is here a rock quarry, about 1¼ miles east of St. Paul. Limestone has been quarried in this vicinity for 30 years. No rock is crushed for roads, but about 500 car loads of bridge material is produced annually. Some 5 acres are covered with about 2 feet of soil. The rock is being excavated to a depth of 28 feet.

St. Paul Stone Quarry Company.—West half of the northwest quarter of section 10 (11 N., 8 E.), Adams Township. This quarry has been operated 40 years, about 30 men being employed. Part of the quarry is in Shelby County. About 180,000 cubic yards have been removed and 5 to 10 acres are easily available. Much of the rock is quarried for road purposes. A crusher is operated and crushed rock is shipped to various parts of the State.

Landis Miller.—Southeast quarter of section 27 (11 N., 8 E.), Clay Township. A gravel pit is located in the old glacial valley referred to above, about a mile and a half north of Milford. It

is in a low ridge 15 rods wide and ½ mile long, rising about 8 feet above the rest of the valley. The gravel runs from ¼ to 1 inch in diameter, is 12 feet thick and underlies 2 feet of soil. About 40,000 cubic yards have been removed. It has been used along the road near, and is being hauled some distance for road purposes. It makes a good road material.

Hamlin Anderson.—Northeast quarter of section 34 (11 N., 8 E.), Clay Township. A gravel pit 1 mile north of Milford has an exposed face of 15 feet with 3 to 6 feet of soil above. The gravel is, for the most part, too fine for roads. About 3 acres are available.

L. C. Bunker.—East half of the southwest quarter of section 3 (10 N., 9 E.), Washington Township. A limestone quarry is here located 2 miles west of Greensburg on the Columbus pike, on Muddy Fork. The rock outcrops on both sides of the creek, rising about 5 feet above it. It has been used for roads in the vicinity. This is a sandy limestone, brownish-gray in color. Samples were secured and tested at the U. S. Road Laboratory, with the following results:

*Results of Physical Tests of Devonian Limestone from land of L. C. Bunker, Greensburg, Decatur County.**

Specific gravity	2.6	French coefficient of wear	8.5
Weight per cu. ft. (lbs.)	159	Hardness	0
Water absorbed per cu. ft. (lbs.)	2.99	Toughness	0
Per cent. of wear	4.7	Cementing value—Dry	8
		Wet	38

"Extremely soft limestone, with about the average toughness and resistance to wear. Cementing value good. Best suited to country road and light highway traffic."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Devonian Limestone from land of L. C. Bunker, Greensburg, Decatur County.

Alumina (Al_2O_3)	.70
Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	34.90
Magnesia (MgO)	17.00
Insoluble in hydrochloric acid	1.78
Loss on ignition	45.86
Total	100.24

*For standard of comparison see p. 79.

From Greensburg to Milford, rock underlies the surface at a depth of 4 to 6 feet.

N. Mowrey.—Northeast quarter of section 12 (10 N., 8 E.), Clay Township. An old rock quarry, not used since 1902, is here located. It is at the edge of a little creek bed and 10 rods south of the road. The outcrop rises about 3 feet above the creek and water must be removed by pumping while quarrying is going on. About 3 miles of pike have been made from this quarry, being finished about 3 years ago. This road is in good condition.

Watson Bostic.—Northwest quarter of section 11 (10 N., 8 E.), Clay Township. In a limestone quarry near the road much the same condition prevails as at the Mowrey place.

Nelson Mowrey.—Southwest quarter of section 4 (10 N., 8 E.), Clay Township. About ½ mile west of the bridge on Clifty Creek and ¼ mile south of the road is a gravel deposit. The pit is about 100 by 20 rods in area. The gravel underlies 3 feet of soil, is ¼ of an inch to 1 inch in diameter and runs 5 to 8 feet in thickness. The pit is situated in a terrace above Clifty Creek, about 40 feet above the bed of the creek, and extending back toward the north about ¼ of a mile, with a width of 10 to 20 rods. Gravel is being hauled 3 miles from here into Shelby County.

J. Barney.—Northeast quarter of section 8 (10 N., 8 E.), Clay Township. A gravel pit has here been opened from which about 2,000 square yards have been taken. The pit is located in what seems to be a portion of a terrace rising about 40 feet above Clifty Creek. The gravel is moderately fine, with no large stones, and runs 4 to 12 feet in thickness, with 2 to 6 feet of soil above. The deposit is a ridge about 10 rods wide and ¼ of a mile long, running nearly due north and south. This is being used on roads in the vicinity and makes a fairly good material.

F. M. Champ.—Southeast quarter of section 7 (10 N., 8 E.), Clay Township. An irregular excavation has been made at the end of a hill overlooking Clifty Creek, and about 45 feet above it. The gravel is much mixed with clay and sand, and is a very poor quality for roads. About 2,500 cubic yards have been removed.

Morgan Miers.—Northwest quarter of section 23 (10 N., 8

E.), Clay Township. A limestone quarry has been opened on a branch of Fall Fork. The rock lies only 2 or 3 feet above water level. About 3 feet of stripping is necessary. A good quality of rock occurs here and much more is available. Six miles of pike have been made from this quarry.

W. E. Woodruff.—Southwest quarter of the northeast quarter of section 33 (10 N., 8 E.), Clay Township. Limestone outcrops here in the bed of a creek, not much above the water level.

J. Jones.—Northwest quarter of the northeast quarter of section 33 (10 N., 8 E.), Clay Township. This place lies adjacent to and north of the Woodruff Place. Rock crops out in the bed of a small stream, which is dry during part of the summer.

Thomas Shirk.—East half of the northwest quarter of section 21 (9 N., 8 E.), Jackson Township. A limestone quarry has been opened in the valley of a small creek. The surface of the rock is about 6 feet below the top of the ground. Seven miles of pike have been made from this quarry. Water stands in the quarry above the level of the limestone.

Sarah Updike.—Northwest quarter of section 29 (9 N., 8 E.), Jackson Township. A small limestone quarry was opened for building 1 to 2 miles of pike south of Waynesburg. The rock was taken out of the creek bed just east of the bridge across Bear Creek, 1 mile south of Waynesburg. From 5 to 6 feet of earth covers the rock.

Greensburg Limestone Company.—Southwest quarter of section 28 (10 N., 9 E.), Sand Creek Township. Ten acres are covered by this quarry, rock having been removed to a depth of 33 feet to "soapstone" below. About 150 acres are yet available, with 2 to 3 feet of stripping. The yearly output of crushed stone is about 300 cars; of other rock, 450 to 500 cars. Thirty to 40 men are employed. The shipments of crushed rock are to various parts of this and adjoining States for use on country roads, traction lines, etc. Samples were tested at the U. S. Road Laboratory with the following results:

*Results of Physical Tests of Niagara Limestone from land of Greensburg Limestone Company, Decatur County.**

Specific gravity	2.7	French coefficient of wear.	9
Weight per cu. ft. (lbs.)	168.4	Hardness	12
Water absorbed per cu. ft. (lbs.)	1.27	Toughness	8
Per cent. of wear	4.5	Cementing value—Dry	61
		Wet	56

"A hard limestone, slightly below the average in toughness and a little above in resistance to wear, with good cementing value. Best suited for highway and country-road traffic."—Page.

An analysis of the stone, made at the same laboratory, showed as follows:

Analysis of Niagara Limestone from land of the Greensburg Limestone Company, Decatur County.

Alumina (Al_2O_3)	.60
Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	49.75
Magnesia (MgO)	2.98
Insoluble in hydrochloric acid	4.27
Loss on ignition	42.17
Total	99.77

Jesse Styers.—Southeast quarter of section 32 (10 N., 9 E.), Sand Creek Township. A gravel pit has recently been opened about 1 mile south of Harris City, west of the road, in a terrace about 40 feet above Muddy Fork. The gravel of these terraces is not considered to be very good and is not used to any great extent on roads. It runs from 6 to 15 feet in thickness, with 3 to 6 feet of stripping necessary.

C. A. Whipple.—Northeast quarter of section 8 (9 N., 9 E.), Sand Creek Township. A limestone quarry is to be opened up for use on pikes in the neighborhood. Rock outcrops at the bottom of a ravine leading into Muddy Fork. It also occurs in many places in the bluffs along the valley from Greensburg south.

J. W. Tremain.—Northwest quarter of section 15 (8 N., 8 E.), Jackson Township. A limestone quarry has just been opened. Three miles of pike are to be made from this quarry. The creek valley is here about 15 rods wide, and the outcrop extends up into the hills, having a clay veneering of drift 3 to 16

*For standard of comparison see p. 79.

feet deep on top. The cost of the pike near here is about $2,650 per mile.

John E. Boicourt.—Northwest quarter of section 18 (8 N., 9 E.), Sand Creek Township. A limestone quarry has been operated here for 20 years. The quarry is in the valley of a small creek. Two miles of pike have been built from the stone and it is in good condition. About 15 acres are yet available, with 4 or 5 feet of stripping.

Nathaniel Gentry.—Southeast quarter of section 13 (8 N., 8 E.), Sand Creek Township. A limestone quarry exists 3 miles south of Westport. Rock is now being removed for a pike 2½ miles long. Outcrops of the stone occur along the ravines leading to Sand Creek, which is here bordered by rocky cliffs 40 feet high. The upper layer at this quarry is a sandy limestone, similar to the sample from the Bunker farm. This layer is now being used for pike making. Below this is a thin layer of shale, then blue limestone.

Westport Stone Company.—Southwest quarter of section 5 (8 N., 9 E.), Sand Creek Township. The yearly output of this quarry is about 1,000 cars, about 150 cars of crushed stone being shipped each year. This is sold in Indiana, Illinois and Ohio. Eighty men are employed. About 20 acres have been removed and 90 acres are yet available, with a stripping of 5 to 15 feet.

Biddinger Bros.—Northwest quarter of section 21 (9 N., 9 E.), Sand Creek Township. This quarry on Muddy Fork has an output of 800 yards of crushed rock and 300 yards of rubble yearly. It is necessary to remove about 2 feet of soil. A 20-foot section of rock can be quarried above the creek bed. Ten acres are available.

Alec Purvis.—Southwest quarter of section 4 (9 N., 9 E.), Sand Creek Township. Limestone outcrops on the side of the valley of Muddy Fork. No quarry has been opened.

Samuel Hodson.—Southwest quarter of section 16 (9 N., 9 E.), Sand Creek Township. Limestone quarries are operated near Biddingers, 20 to 50 acres being available.

The Magness Place.—Northeast quarter of section 12 (9 N., 9 E.). Marion Township. Limestone outcrops along Sand Creek, rock for the Greensburg-Milhausen pike being taken from here.

On Muddy Fork rock crops out from near the bridge on the Columbus-Greensburg pike to the junction with Sand Creek. Panther Creek has rock from section 24 (9 N., 9 E.) to its mouth. Squaw Creek has outcrops of rock from near Milhausen to its junction with the North Fork of Muscatatuck River.

E. J. Forkert.—Southwest quarter of section 35 (10 N., 10 E.), Salt Creek Township. An outcrop of limestone here marks the upper limit of limestone on the North Fork of the Muscatatuck River.

Thomas Smith.—Northeast quarter of section 21 (10 N., 10 E.), Washington Township. A limestone quarry on Sand Creek is now being used for a pike near by. Three miles of road are being built this year. A good blue limestone is found here, the outcrop being in the creek bed. Sand Creek from here to Scipio has more or less limestone cropping out in its channel and banks

Clay Castor.—East half of the southwest quarter of section 32 (10 N., 11 E.), Salt Creek Township. Limestone appears on Leather Creek on this farm, and may be expected to crop out farther down the valley.

Big Four Stone Company.—Southwest quarter of section 8 (10 N., 11 E.), Salt Creek Township. About 6 acres have been excavated to a depth of 10 to 20 feet One hundred and 20 acres are available with 1 to 12 feet of stripping. Forty to 50 men are employed. The yearly output is 630 car loads. About 100 cars of crushed stone are produced annually. Samples of this stone were sent to the Road Testing Laboratory at Washington, with the following results:

*Results of Physical Tests of Niagara Limestone from land of Big Four Stone Company, New Point, Decatur County.**

Specific gravity	2.7	French coefficient of wear	11.3
Weight per cu. ft. (lbs.)	168.4	Hardness	9.3
Water absorbed per cu. ft. (lbs.)	.93	Toughness	10
Per cent. of wear	3.5	Cementing value—Dry	12
		Wet	34

"**A rather** hard limestone, slightly above the average in toughness and **above the average** in resistance to wear, with fairly good cementing value. **Suitable for** highway and country-road traffic."—Page.

*For standard of comparison see p. 79.

An analysis of the sample made at the same laboratory showed the following results:

Chemical Analysis of Niagara Limestone from land of Big Four Stone Company, New Point, Decatur County.

Alumina (Al_2O_3)	1.00
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	44.85
Magnesia (MgO)	7.24
Insoluble in hydrochloric acid	2.95
Loss on ignition	43.21
Total	100.10

Henry Hascamp.—Northeast quarter of section 6 (10 N., 11 E.), Fugit Township. Limestone outcrops on a small creek. Three miles of pike have been made from this place. About 3 acres are available.

N. Herrick.—Northeast quarter of section 19 (11 N., 11 E.), Fugit Township. A limestone quarry occurs 2 miles north of St. Maurice.

Jesse Plue.—Southeast quarter of section 9 (11 N., 11 E.), Fugit Township. A quarry was opened here and a crusher started, but the rock was condemned by the county surveyor. The stone is a coarse, granular, yellowish limestone, rather soft. Where it has been used for 4 or 5 years on a small piece of pike, it has worn fairly well.

Fred Huber.—Northeast quarter of section 21 (11 N., 11 E.), Fugit Township. Limestone crops out on the bank of Right Hand Fork.

J. King.—Northeast quarter of the southwest quarter of section 34 (12 N., 9 E.), Adams Township. A pit by the road near the house on the higher terrace of Little Flat Rock Creek shows gravel 6 feet thick and ¼ of an inch in diameter, with some stones 3 to 12 inches in diameter. About 1,000 cubic yards have been removed and 2 acres are yet available.

Orlando Lee.—Southeast quarter of the northwest quarter of section 34 (12 N., 9 E.), Adams Township. A gravel pit on this place is in an extension of the deposit found on the King farm. About the same amount has been removed. Two acres are yet available.

Harry Hayes.—Southwest quarter of section 32 (12 N., 9 E.), Adams Township. 'A limestone quarry has been opened on Flat Rock Creek about 1½ miles north of Downeyville. Three thousand 500 cubic yards have been removed.

R. T. Lemons.—South half of the southwest quarter of section 32 (12 N., 9 E.), Adams Township. A limestone quarry exists south of Flat Rock Creek. This quarry is operated on a small scale, similar to that of the Hayes quarry. The outcrop rises 30 feet above the creek. Some 15 acres of surface are easily available at these quarries.

Wesley Garrett.—Southeast quarter of section 31 (12 N., 9 E.), Adams Township. Here is a limestone quarry called the "McNeely quarry." About the same method and amount of work is carried on as in the two quarries previously mentioned.

Joseph Garrett.—Northeast quarter of section 31 (12 N., 9 E.), Adams Township. A gravel pit here occurs with about 5 acres yet available.

Lafe Shellhorn.—Southwest quarter of section 5 (11 N., 9 E.), Adams Township. A small limestone quarry exists near the bridge over Little Flat Rock at Downeyville. The creek has rocky banks 10 to 20 feet high. Rock occurs in the bed and the banks of Flat Rock Creek and its branches throughout the county. On Clifty Creek rock outcrops from a point 2 miles east of Sandusky to its exit from the county.

J. A. Carr.—Northeast quarter of section 7 (11 N., 10 E.), Clinton Township. Limestone appears in the creek bed and from it has been quarried enough rock for about 6 miles of pike between Sandusky and Clarksburg.

About 2 miles above the junction of Little Flat Rock with Flat Rock and on the south side of the former there is an extension of the "second bottom," apparently part of the old valley which shows up west of the Pleake place. Gravel appears along the road where a cut has been made. It is probable that this old valley contains much gravel. Across the bridge to the west, on Lafe Shellhorn's place, a pit has been opened at the edge of this high terrace, which shows gravel 10 to 15 feet thick beneath 1 to 2 feet of soil. At present the showing is rather fine gravel. This is but an example of the extensive deposits of gravel lying between Flat

Rock and Little Flat Rock creeks. All the region lying between these streams as far north as about a mile south of the county line may be expected to produce gravel at a depth of 2 to 3 feet. Also on the right bank of Big Flat Rock Creek the gravelly terrace appears to a width of about half a mile and at a height above the creek of about 40 feet.

John Shellhorn.—Southwest quarter of section 6 (11 N., 9 E.), Adams Township. A gravel pit has been opened 1 mile west of Downeyville about a quarter of a mile above the fork of the creek and between its branches. The gravel is 8 feet in thickness and rather coarse, ½ to 1½ inches, with stones 2 to 6 inches in diameter scattered through. It is overlain with 2 feet of soil and underlain with 6 feet of coarse sand.

Raymond Leach.—Southwest quarter of section 6 (11 N., 9 E.), Adams Township. There is a gravel pit west of the bridge on Flat Rock, just above the fork. The gravel is moderately fine, but towards the stream is coarse and bouldery.

Clifty Creek.—Southwest quarter of section 10 (11 N., 9 E.), Adams Township. Rock outcrops in the bed of the creek at this bridge. Gravel could possibly be obtained in small quantities on the north side of the creek, above the bridge, on "first bottom." No high terrace gravel appears here.

W. W. Hamilton.—Southeast quarter of section 16 (11 N, 10 E.), Fugit Township. Limestone has been quarried from the creek here, but during late years no rock has been used on roads, as the owner was unwilling to dispose of the rock to the township trustees.

Big Four Railroad Grade.—Northeast quarter of section 12 (10 N., 9 E.), to northeast quarter of section 15 (10 N., 10 E.), Washington Township. This is an abandoned railroad grade, and offers a supply of probably 10,000 yards of gravel. It is moderately coarse, being ¼ of an inch to 1 inch in diameter, with some larger stones. This gravel is now being used to repair the Greensburg-Kingston pike.

Benjamin Garver.—Northwest quarter of section 21 (10 N., 9 E.), Washington Township. Limestone from the quarry here has been used in making several miles of pike in the township.

Mr. Turner.—Northwest quarter of section 23 (10 N., 9 E.),

Washington Township. A limestone quarry has been in use for many years and much stone has been taken out for roads in the vicinity. The rock is obtained partly from the bed of the creek and partly from the banks.

BARTHOLOMEW COUNTY.

Area in square miles	400
Population in 1900	24,594
Miles of public roads	900
Miles of improved roads	276
Percentage of roads improved	30.6
Miles improved with gravel	250
Miles improved with crushed stone	26
Average original cost of gravel roads per mile	$2,000
Average original cost of stone roads per mile	$3,200
Total original cost of improved roads	$583,200
Annual cost of repairs per mile on gravel roads 5 years old	$60
Annual cost of repairs per mile on stone roads 5 years old	$60
Miles of improved roads (gravel) built in 1905	15
Miles of improved roads (stone) built in 1905	4
Miles of improved roads (gravel) contracted for 1906	2½
Miles of improved roads (stone) contracted for 1906	3½
First improved roads built	1886
Proportion of improved roads built since 1895 (per cent.)	70
Satisfaction of farmers with investment in improved roads	Good
Authority	Wm. A. Morris, County Auditor

The most striking feature in respect to road making in this county is the extensive deposit of gravel that occurs in the valley of White River. The area of this deposit is not less than 100 square miles, one-fourth of the whole area of the county. The gravel usually has from 2 to 4 feet of soil on top. In the places where it may be most easily secured, the gravel forms ridges slightly above the surrounding level bottom. These ridges are quite frequent over most of the bottom land and may be detected by careful observation of the undulations of a plowed field or by the retarded growth of corn over these gravelly patches. The depth of this gravel deposit is undefined over most of the area, but wells have penetrated 50 feet or more of gravel. It is probable that the gravel reaches to even a greater depth in some places. It is, however, not practicable to excavate much below the water level, which is reached generally at a depth of 10 feet on the

lower bottom or terrace, and at about 30 feet on the higher terrace. The size of the gravel is usually 1/4 inch to 1/2 inch in diameter, with some sand and some layers of pebbles. Pits have been opened here and there throughout the valley, but there is practically no limit to the number of places where gravel may be taken out.

In addition to the deposits in White River valley, there is another source of gravel which furnishes abundant and suitable material for roads in this and neighboring counties. This is the outcrop of Knobstone shales which rises in high hills along the western border of the county. A 3-mile strip along the west edge of Bartholomew County embraces most of the area where this gravel is found. It consists of pieces of iron oxide and of sand concretions cemented by iron oxide. In size it varies from 1/4 inch to 1 inch in diameter. It is a moderately soft material, crushing readily by continued traffic into a compact mass, which cements together, forming a smooth and solid surface. This gravel may be found in all the streams running out of the Knobstone hills, and for a distance of about 2 miles from where it was derived. These two gravels vary considerably in regard to their suitability as road metals. The hard gravel of the White River valley requires at least a year to become packed sufficiently to make a good surface. The softer gravel from the hills packs quickly. While the former is comparatively resistant to traffic at all seasons of the year, the latter is liable to "cut through" when frost is coming out of the ground. Samples of this Knobstone gravel from Wolf Creek were tested at the Road Laboratory at Washington, and the results show its dry grinding cementing value to be 74, and the wet grinding 190.

A width of 5 miles through the east side of Bartholomew County is provided with limestone of good quality. This is quarried in several places, and rock instead of gravel is here used for road making.

W. J. Cook.—Part of the east half of the northeast quarter of section 28 (10 N., 5 E.), Union Township. A gravel pit has been opened about 1/4 of a mile east of the road. About 15,000 cubic yards have been removed, being used on the roads of the vicinity. The gravel averages 1 inch in diameter, and runs 10 feet thick, with 2 feet of soil above.

Mary E. Royce.—Southeast quarter of section 21 (10 N., 5 E.), Nineveh Township. A gravel pit 300 by 70 yards in area and 6 feet deep has here been opened. The gravel is about like that in the Cook pit and has 2 feet of soil above it. Material for about 4 miles of road has been secured from this pit. The road is now in good condition after being in use about 6 years. It has been repaired every year with gravel from Hickey's pit.

John Hickey.—Southwest quarter of section 16 (10 N., 5 E.), Nineveh Township. A gravel pit is situated in a low ridge 100 by 85 yards. Four miles of road have been made from this pit and the road is in very good condition. The gravel is about 6 feet thick, with about 30 inches of soil above.

James D. Barnhill.—Southwest quarter of section 7 (10 N., 5 E.), Nineveh Township. At the junction of Mud and Nineveh creeks a gravel hill rises to a height of 60 feet above the creek bed. Gravel is exposed on the sides, while on the east slope it has been removed in quantity. It is overlain with 1 to 3 feet of soil. Near the top is a layer 1 to 2 feet thick of finely cemented gravel. This crops out in heavy ledges on the west side of the hill for 200 yards. Below the cemented layer down to the level of the creek the gravel is mostly loose but arranged in a somewhat stratified manner, the planes of stratification dipping toward the southwest at an angle of 15 to 20 degrees. The gravel ranges in size from 1/4 of an inch to 2 inches in diameter, and there are many large boulders 4 to 20 inches in diameter. Limestone, shale, greenstone and quartz pebbles are frequent. Two and one-half miles of road, southeast of Kansas, were built from this pit 5 years ago. The gravel packs well and the road is in good condition at present.

A. E. Royce.—Northeast quarter of section 2 (10 N., 4 E.), Nineveh Township. A knoll of gravel with no soil on top exists here, about 3,000 cubic yards being available. One-fourth of a mile of road has been made from this pit. The pike from Kansas to Edinburg was made from gravel taken from Nineveh Creek, Driftwood River and the Joseph Watts farm. It was built 20 years ago, and is now a good road.

John Royce and Granville Smith.—Southwest quarter of section 13 (10 N., 4 E.), Nineveh Township. A pit has been opened up in the barnyard near the base of a hill. A similar de-

posit to that found on the Barnhill farm is here exposed. There is a cemented portion above 5 to 7 feet of gravel. Across the fence on the Smith place a thicker section is shown. No stripping is necessary. Two and a half miles of pike were built from these pits in the fall of 1904, running south from the west side of Royce's farm.

Lewis Royce.—Southwest quarter of section 13 (10 N., 4 E.), Nineveh Township. Gravel is exposed on a hill where the road has been cut through. At the top there are 2 or 3 feet of red sandy clay. There is some cemented gravel here, as in the last two places described. The cliff faces the northwest and the material is arranged in arched strata. The hill to the north is cut to a depth of 12 feet, and shows only red gravel, or coarse, sandy clay. Gravel from this pit, with a gravel from the John Royce place, was used on the pike near by, having been put on in 1904. It wears well, but on the hillsides is badly washed. This gravel deposit seems to be an extension of the deposit on the John Royce and Barnhill places, which are doubtless more or less connected through the high hill which separates them.

John Long.—Southeast quarter of section 23 (10 N., 4 E.), Nineveh Township. In the bed of a small creek leading from the hills at the west, gravel is found in considerable quantities, occurring both in the channel and in the banks of the stream. It consists of flat fragments of fine, shaly sandstone cemented with iron oxide and glacial boulders, the latter frequently reaching the diameter of 8 inches, but mostly smaller. About 2 miles of pike were made from this kind of material in September, 1904. The gravel packs well and forms a hard, smooth surface.

P. N. Daum.—Northwest quarter of section 6 (9 N., 4 E.), Union Township. On the south side of a little valley running through this farm there is an outcrop of cemented gravel like that on the Barnhill place. No material has been taken out, but the indications are such as to suggest an extensive deposit.

J. Q. Owens.—Northwest quarter of section 7 (9 N., 4 E.), Union Township. There is about 1½ miles of gravel on Catherine Creek, beginning about ¼ of a mile west of section 7 and extending up the stream. Bless Creek, just south, has little or no gravel. Most of that which has been used on the roads south of

Bless Creek came from Driftwood River, 1 mile south of Lowell Mills.

Dr. Wright.—Southwest quarter of section 22 (9 N., 5 E.), Columbus Township. Two miles west of Columbus, in the bed of Driftwood River, is a gravel bar from which material is hauled frequently. It is about 200 by 25 yards in area, and averages 3 feet deep. High water always brings in fresh gravel to renew places from which it has been removed, so that there is a never failing supply. In size the gravel varies from coarse sand to 2 inches in diameter. Much has been used on pikes near by and at a distance. The pike running west from Columbus up the valley of Wolf Creek was built largely from these bars many years ago. It is in fair condition, but becomes loose and dusty on top soon after damp weather has ceased.

Valentine Ault.—North half of section 30 (9 N., 4 E.), Harrison Township. Gravel sets in in Wolf Creek at the bridge ½ mile west of this farm, and extends to the hills. The amount obtainable at different places along this stream is variable.

S. C. Daugherty.—Southwest quarter of section 12 (8 N., 5 E.), Wayne Township. A gravel pit 500 by 90 yards in area, lying along the P., C., C. & St. L. Railway, a quarter of a mile northwest of Walesboro, has been opened. It shows the following section:

Section at gravel pit of S. C. Daugherty, Wayne Township, Bartholomew County.

	Feet.	Inches.
1. Soil, reddish, sandy	3	..
2. Sand	1	2
3. Gravel, mostly fine, averaging about one-fourth inch in diameter	10	..

The magnitude of this excavation shows the great prevalence of gravel as an underlying deposit in this valley. This gravel pit has been used by the railway company.

Sherman Swaney.—Northwest quarter of section 12 (8 N., 5 E.), Wayne Township. A gravel pit lies just across the road from the Daugherty place. It is 80 by 30 yards in area and is the same kind of deposit in every way as the other.

Many gravel bars are found in the channel of White River between Columbus and Azalia.

C. E. Massie.—Northwest quarter of section 33 (8 N., 6 E.).

Wayne Township. A gravel bar occurs in White River at this place. It is 250 by 50 yards in area and 3 feet deep above low water. The gravel averages about 1/4 of an inch in diameter.

Mr. Spurgeon.—Northwest quarter of section 32 (8 N., 6 E.), Wayne Township. There is here a gravel pit about 150 yards in diameter and 12 feet deep.

A. Kiel.—Northwest quarter of section 16 (7 N., 6 E.), Wayne Township. About 1½ miles southeast of Jonesville is a gravel pit in a pasture near the road. It is about 100 yards in diameter.

Section of gravel pit on land of A. Kiel.

	Feet.	Inches.
1. Soil, dark colored, pebbly	1	6
2. Gravel, one-fourth to one-half inch in diameter with finer material	4	6

At least 5 acres occur in the same ridge. There is not much demand for this gravel at 5 cents a yard. Mr. Kiel has also 6 or 7 gravel bars in the river, of 5 to 10 acres each.

Southern Indiana Railway Gravel Pit.—Northwest quarter of section 3 (7 N., 6 E.), Sand Creek Township. A pit 400 by 200 yards in area has here been opened. Gravel has been used for ballast on the railroad. It is much mixed with sand and, in general, is too fine for roads. It runs about 7 feet thick with 3 feet of pebbly soil above.

Lewis Davis.—Southwest quarter of section 3 (7 N., 6 E.), Sand Creek Township. From a gravel bar in White River at this point the pike south of Azalia was being made.

Frank Crump.—Southwest quarter of section 10 (7 N., 6 E.), Sand Creek Township. A gravel bar here occurs, about 3/4 of a mile below the Davis bar. These two gravel bars each comprise about 15,000 cubic yards.

N. Newsom.—Northwest quarter of section 28 (8 N., 6 W.), Sand Creek Township. A gravel pit 50 by 30 yards in area has been opened near White River 1 mile west of the Azalia-Columbus pike. The gravel averages 3/8 of an inch in diameter and runs 10 feet thick, with 2 feet of dark, gravelly soil above.

John Crump.—Northeast quarter of section 20 (8 N., 6 E.), Sand Creek Township. A gravel pit 100 by 200 yards in area is located about 1/2 mile east of the river and 3½ miles northeast of Azalia.

Clifty Creek.—There is a gravel bar about ½ mile above the bridge on the Azalia-Columbus pike, on the line between section 32 (9 N., 6 E.) and section 5 (8 N., 6 E.), Columbus Township. Much gravel has been taken from this deposit for the pike near by.

A. McEwen.—East half of section 31 (9 N., 6 E.), Columbus Township. A gravel pit 50 by 30 yards in area occurs here which shows the following:

Section of gravel pit on land of A. McEwen.

		Feet.
1.	Soil, gravelly	3
2.	Sand	6
3.	Gravel, ½ inch in diameter	8

Gravel from here was used on the pike 20 years ago. The road is in good condition. The gravel has been taken out from the point of a knoll running northwest from the residence. The top of this knoll is 35 feet above low water in White River.

John Beatty.—Columbus Township. Mr. Beatty has four gravel bars in White River, comprising 100 acres, with an average depth of 2 feet. Much has been used for piking roads near Columbus.

The "State Road," running southeast from Columbus, was piked many years ago with river gravel and pit gravel. It is in rather poor condition, owing to the fact that the gravel is too fine to pack, and 2 or 3 inches of the top is always loose.

Near the Columbus-Indianapolis interurban line bridge at Columbus there is a pit 70 by 70 yards in area, from which gravel was taken for ballasting the interurban track. It shows 3 feet of gravel, ¼ to ½ inch in diameter, overlain with 4 feet of brownish pebbly soil.

Lowell Station.—Northeast quarter of section 11 (9 N., 5 E.), Columbus Township. There is here a railroad gravel pit 275 by 275 yards in area which shows 6 feet of gravel overlain with 4 feet of brown pebbly soil. The material taken out of this pit was used as ballast on the railroad.

Isaac Bredin.—Southeast quarter of section 9 (10 N., 5 E.), German Township. A gravel deposit here occurs which is the result of overwash from a break in the dike. About 1,000 cubic

yards have been removed and as much more is lying on the ground. This is being used on roads in the vicinity and is of good quality.

Driftwood River.—Southwest quarter of section 4 (10 N., 5 E.), German Township. Near the bridge on the Kansas-Edinburg road is a gravel bar from which material was taken for pikes in the neighborhood.

Flat Rock Creek has much gravel from where it enters the county to its junction with Driftwood River, while the latter stream has gravel only in occasional bars. From Flat Rock comes most of the gravel used on the pikes in German Township. The roads made of it are good, though built many years ago.

John Ward, of Hope, has a gravel bar in Flat Rock Creek, about half a mile up stream from the bridge west of St. Louis Crossing. Of this, 10,000 cubic yards have been removed for use on the roads in the vicinity. Much of the gravel used near Hope is brought from Flat Rock Creek.

H. Snider.—Northeast quarter of section 18 (10 N., 7 E.), Haw Creek Township. Just at the edge of the village of St. Louis there is a large gravel pit in the hill on which the house and barn are standing. It is 70 by 60 yards in area and averages 18 feet in depth. The excavation has proceeded so far as to threaten the safety of the foundation of the house. Much of the material is sandy or gravelly soil. The best gravel is in a buried ridge, which runs under the house. About 20 miles of road have been made from this pit. It makes a good road, remaining smooth and firm.

The roads about St. Louis are unusually good. In one part of the deposit above mentioned cemented gravel appears. Mr. Snider says that after blasting through this cemented layer no gravel was found below. This deposit is also outside the limits of the ordinary valley deposit farther west, and bears evidence of glacial deposition. There is a partial stratification, with the dip towards the northwest.

Mr. Bowman.—Southwest quarter of section 6 (10 N., 7 E.), Haw Creek Township. A gravel pit is located in a field a quarter of a mile southeast of the residence. The pit was just being opened when it was visited by the writer. The deposit is at the edge of a little valley, and on the southeast slope of a hill rising some 30 feet to the west. There is an acre or so available.

Section at Bowman gravel pit.

		Feet.
1.	Soil, coarse, pebbly	2
2.	Boulders, 2 to 6 inches in diameter	1
3.	Gravel, ¼ to 1 inch in diameter	2+

Mr. Harker.—Northeast quarter of section 9 (10 N., 7 E.), Haw Creek Township. A gravel pit is located at the edge of the woods a quarter of a mile west of the road. Its area is 40 by 60 yards, and is about 14 feet deep at one end, running out to the surface on the hillside. The deposit is in the form of a buried ridge running back into the hill, the end being exposed in the pit. About six feet of clayey soil rests on the top and sides of the gravel ridge, a cross section of which is probably eight feet high and twelve feet wide. The gravel is from half an inch to one and a half inches in diameter and contains some boulders six to ten inches in diameter. It is rather difficult of access and is now used only for repairing roads. A three-foot hole dug in the top of the hill 30 yards farther back shows coarse gravel at the bottom.

Lewis Solomon.—Northwest quarter of section 20 (10 N., 7 E.), Haw Creek Township. A limestone quarry northwest of Hope is located on the west bank of Haw Creek. This quarry has produced rock for about ten miles of road. The stone is a moderately hard limestone, and by some is thought to be better for roads than is the blue limestone, since its softer quality permits it to pack more readily. The top of the formation is about 12 feet above Haw Creek, and the rock extends back into the hill indefinitely. There is too great a depth of soil on top to make a paying quarry, except just along the outcrop. A crusher is located here.

Samples of this stone were secured and sent to the U. S. Road Laboratory for testing, with the following results:

*Results of Physical Tests of Devonian Limestone from land of Lewis Solomon, near Hope, Bartholomew County.**

Specific gravity	2.7	French coefficient of wear	6.7
Weight per cu. ft. (lbs.)	171.5	Hardness	—1
Water absorbed per cu. ft. (lbs.)	1.71	Toughness	5
Per cent. of wear	5.9	Cementing value—Dry	20
		Wet	41

"Fair resistance to wear and fairly good cementing value. Best suited for country-road traffic."—Page.

*For standard of comparison see p. 79.

An analysis of the stone, made at the same laboratory, showed the following results:

Analysis of Devonian Limestone from land of Lewis Solomon, near Hope, Bartholomew County.

Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	55.70
Magnesia (MgO)	.23
Phosphoric acid (P_2O_5)	Trace
Insoluble in hydrochloric acid	.86
Loss on ignition	43.32
Total	100.11

Sarah Trotter.—Northeast quarter of section 32 (10 N., 7 E.), Haw Creek Township. About two miles south of Hope a quarry of limestone is being opened up An area 10 by 40 yards has been removed to a depth of 12 feet. With from 3 to 10 feet of stripping, 20 acres could be quarried. The stone is much the same as that on the Solomon farm. Two miles of pike have been made from this quarry, the rock being sold at eight cents per cubic yard.

John Keller.—Southwest quarter of section 8 (9 N., 7 E.), Clay Township. A gravel pit just south of the township line bridge on Clifty Creek, about a mile west of Newbern, is 80 by 80 yards in area. This pit has been used 25 or 30 years, and some 50 miles of pike have been made from it. About 40 acres are yet available. The soil is two feet deep, below which is some 12 feet of gravel, alternating with layers of sand or of coarse material and containing some boulders up to one foot in diameter.

Mr. McCauley.—East half of section 8 (9 N., 7 E.), Clifty Township. About ten rods northeast of the Keller pit is a newly opened gravel pit in an extension of the same terrace.

Mr. Shafer.—Southwest quarter of section 5 (9 N., 7 E.), Clay Township. From a quarry located back of the barn some rock has been removed for foundations. This rock is in thick layers and is a moderately compact stone. With a stripping of one to six feet, five or ten acres would be available.

D. Hopkins.—North half of section 22 (10 N., 7 E.), Haw Creek Township. Here is a limestone outcrop, but no quarrying

has been done. About one mile east, on Duck Creek, limestone outcrops in the bed of the creek.

Arthur Galbraith.—Southwest quarter of section 25 (10 N., 7 E.), Haw Creek Township. A gravel pit three-fourths of a mile north of Hartsville, on the west side of Clifty Creek, is in an area of terrace containing about two acres.

Dr. Morrison.—Southwest quarter of section 36 (10 N., 7 E.), Haw Creek Township. On the west side of Clifty Creek, just below Hartsville, rock outcrops about 30 feet above the creek. A quarry has been lately opened, the rock being used mainly for building purposes. The quantity is unlimited.

John Collins.—Southwest quarter of section 36 (10 N., 7 E.), Haw Creek Township. A limestone quarry is located west of Clifty Creek, one-fourth of a mile southwest of Hartsville. It is 100 by 40 yards in area. Little stripping is necessary and unlimited amounts are available.

W. B. Davis.—Northwest quarter of section 18 (9 N., 7 E.), Clay Township. On the south side of Clifty Creek there is a gravel pit 100 by 30 yards in area and 12 feet deep. The quality is about like that of the gravel on the Keller farm.

William Henderson.—Northwest quarter of section 14 (9 N., 6 E.), Clay Township. A gravel pit is located by the road in the side of the bank of a small run leading into Clifty Creek from the north. About 400 square yards in area have been removed. Twenty-five acres could probably be utilized. There are two feet of soil above the six or eight feet of gravel. The latter contains some boulders as large as six inches in diameter, and many chert nodules.

Township Gravel Pit.—Southwest quarter of section 14 (9 N., 6 E.), Clay Township. Just across the road from the Henderson pit is a gravel pit owned by the township. In area it is 20 by 50 yards, and has been opened to a depth of 12 feet.

James Perry.—Southeast quarter of section 14 (9 N., 6 E.), Clay Township. A gravel pit located west of the road, about a quarter of a mile south of Petersville, is 150 by 150 yards in area. Gravelly soil to a depth of one or two feet covers the gravel, which is coarse, with some boulders six inches in diameter. There is a depth of 12 feet of gravel. To the northwest the deposit ex-

tends over probably 15 acres, while east of the road there are about 20 acres. From this pit gravel for the northern part of the township is secured, while from the Keller pit the south central part of Clay Township is supplied.

Roads in the central part of Clifty Township are not improved to any great extent. Material has to be hauled from Clifty Creek or from rock quarries farther east. The road on the line between sections 20, 21 and 28, 29 (9 N., 7 E.), is now being graveled from the Keller pit.

John Carter.—Southwest quarter of section 23 (9 N., 7 E.), Clifty Township. Limestone outcrops about two miles west of the county line and one mile north of the south line of Clifty Township. Much material is available. Limestone also outcrops on the farm of Mr. Hamm, northeast quarter of section 27 (9 N., 7 E.), Clifty Township.

N. Bradley.—Northeast quarter of section 10 (9 N., 7 E.), Clifty Township. A gravel pit located on the south side of Clifty Creek, 40 by 30 yards in area, is in a terrace about 30 feet above the creek. Towards the creek the material is coarse, containing many boulders six or eight inches in diameter. Farther away the material gradually becomes finer. The appearance of a section taken at right angles to the stream indicates that the coarse material near the stream was first deposited, then the finer parts were successively laid down across the top and beyond the coarser part. From two to three feet of soil lies on top. About one-third of the material is of boulders too large for road purposes. Five acres are available. About 15 rods south of this pit a sandy limestone outcrops some 40 feet above the creek.

William Brockman.—West half of section 12 (9 N., 7 E.), Clifty Township. A gravel pit has been opened at the north end of a hill rising some 40 feet above the valley bottom, in which it stands isolated from other high lands to the west. The whole hill, which is a quarter of a mile long and 40 rods wide, has the appearance of being made up largely of gravel. The average size of this gravel is half an inch in diameter, with some boulders six inches in diameter.

Combs Anderson.—Southwest quarter of section 12 (9 N., 7 E.), Clifty Township. On Falls Fork there is a terrace about 30

feet above the stream. It seems to be made up partly of gravel and partly of underlying limestone. At the house of Mr. Anderson, in digging a cistern, rock was struck at ten feet. Farther north of the house gravel outcrops at the edge of the terrace. Much rock is found all along this creek. It has been used to some extent on the pikes west of here, and it wears well. A crusher has been located on this creek for several years, but no rock has lately been crushed.

Section at the Falls of Falls Fork.

	Feet.	Inches.
1. Limestone, hard	3	6
2. Limestone, shaley	..	6
3. Limestone, soft, clayey	1	6
4. Shale	6	6

The limestone of the ledge No. 1, over which the water falls, is continuous up the side of the ravine some 25 feet.

F. W. Barbour.—Northeast quarter of section 4 (8 N., 7 E.), Rock Creek Township. About a quarter of a mile south of the road and a quarter of a mile west of Burnsville there is a gravel pit 150 by 20 yards in area. Under two feet of soil there is some four feet of rather fine gravel, containing much clay. About six miles of pike have been made from this pit. After seven or eight years' use the road is firm and smooth. The clay in this gravel seems to be of proper amount to make a solid road when the material is subjected to continuous traffic. The deposit is, however, about used up. One-fourth of a mile to the northwest is another pit 30 by 50 yards in area, but here, likewise, the gravel is nearly exhausted.

Mrs. C. Huffman.—Northwest quarter of section 3 (8 N., 7 E.), Rock Creek Township. A limestone quarry has been opened at the east edge of Burnsville. It is 100 by 15 yards in area and rock rises to a height of 12 to 20 feet above the creek. Less than ten feet of stripping is necessary to lay bare two or three acres.

David M. Walker.—Northeast quarter of section 6 (8 N., 7 E.), Rock Creek Township. A limestone quarry and lime kiln are situated on the south side of Little Sand Creek on this farm. Exposures are visible for 40 rods or more along this part of the creek.

Section of quarry on land of D. M. Walker.

		Feet.	Inches.
1.	Soil	6 to 10	..
2.	Shale	3	..
3.	Limestone, hard, blue	2	..
4.	Limestone, medium hardness, gray	..	8
5.	Limestone, soft, buff	7	4

White limestone continues below the level of the excavation indefinitely. The base of the buff-colored limestone is about ten feet above the creek. Some four or five acres would be available with little or no stripping. Stratum No. 3 is very hard and will not burn into lime. It makes a fine road metal, but is slow in packing. No. 4 is softer and makes a good road. No. 5 is a good stone for making lime and for roads. Its lasting qualities are not quite so good as are those of the blue. Mr. Walker has sold some stone for roads, but no crusher has been operated at the quarry.

Samples of this stone were sent to the Road Testing Laboratory at Washington for testing, with the following results:

*Results of Physical Tests of Devonian Limestone from land of D. M. Walker, Burnsville, Bartholomew County.**

Specific gravity	2.7	French coefficient of wear	6.7
Weight per cu. ft. (lbs.)	168.4	Hardness	—8.3
Water absorbed per cu. ft. (lbs.)	.96	Toughness	5
Per cent. of wear	6	Cementing value—Dry	18
		Wet	25

"Best suited for country-road traffic."—Page.

An analysis of the sample made at the same laboratory showed as follows:

Chemical Analysis of Devonian Limestone from land of D. M. Walker, Burnsville, Bartholomew County.

	Per cent.
Alumina (Al_2O_3)	.11
Iron oxide (Fe_2O_3)	.51
Lime (CaO)	52.70
Magnesia (MgO)	.51
Phosphoric acid (P_2O_5)	1.08
Insoluble in hydrochloric acid	3.51
Loss on ignition	41.68
Total	100.10

"The sample is unusually rich in phosphoric acid."

*For standard of comparison see p. 79.

Oscar Case.—Northeast quarter of section 6 (8 N., 7 E.), Rock Creek Township. At this place there is a limestone quarry on Little Sand Creek, 100 by 50 yards in area.

Section of quarry on land of Oscar Case.

		Feet.
1.	Soil	6
2.	Shale	1 to 2
3.	Limestone, blue	1½ to 2
4.	Limestone, gray	1½ to 2
5.	Limestone, buff, with two layers of chert nodules 4 to 5 in. thick	8

The base of the last layer is about four feet above the creek bed. The quarry was opened in 1891. A mile and three-quarters of the Burnsville-Columbus pike were made from this quarry, parts of each layer having been used. About ten acres are available without much stripping.

George Taylor.—Northeast quarter of section 5 (8 N., 7 E.), Rock Creek Township. There is an old limestone quarry on Little Sand Creek, similar to the Case quarry. It is little worked now.

Charles Boody.—Southwest quarter of section 12 (8 N., 6 E.), Sand Creek Township. A gravel pit 40 by 50 yards in area shows a depth of soil two feet, then gravel containing many boulders six to ten inches in diameter five feet, and below this sand one or more feet in depth. About two acres are available. The pit being situated in that part of the deposit lying nearest to the creek, it is possible that, farther back in the unworked portion, gravel of a more even size may be found. Material from this pit has been used in repairing roads near Elizabethtown.

Mrs. Ryan.—Northeast quarter of section 16 (8 N., 7 E.), Rock Creek Township. Rock for six miles of pike was here blasted out of Rock Creek bed. There is much more available.

M. A. (A. D.) Rainey.—West half of the northeast quarter of section 12 (8 N., 7 E.), Rock Creek Township. About three miles of pike have lately been made from a quarry located on this place. About five acres are available. This quarry has been operated for 40 years. Samples tested at the U. S. Road Laboratory showed the physical properties to be as follows:

*Results of Physical Tests of Devonian Limestone from land of M. A. Rainey, Grammar, Bartholomew County.**

Specific gravity	2.5	French coefficient of wear	6.5
Weight per cu. ft. (lbs.)	159	Hardness	8
Water absorbed per cu. ft. (lbs.)	1.37	Toughness	8
Per cent. of wear	6.2	Cementing value—Dry	38
		Wet	49

"A fairly hard, though not very tough limestone, with rather low resistance to wear, but good cementing value. Best suited to country-road traffic."—Page.

An analysis of the sample, made at the same laboratory, showed the following results:

Chemical Analysis of Devonian Limestone from land of M. A. Rainey, Grammar, Bartholomew County.

	Per cent.
Alumina (Al_2O_3)	.71
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	53.35
Magnesia (MgO)	.22
Phosphoric acid (P_2O_5)	.54
Insoluble in hydrochloric acid	2.65
Loss on ignition	42.10
Total	99.82

JACKSON COUNTY.

Area in square miles	520
Population in 1900	26,633
Miles of public roads	650
Miles of improved roads	500
Percentage of roads improved	76.9
Miles improved with gravel	490
Miles improved with crushed stone	10
Average original cost of gravel roads per mile	$1,057
Average original cost of stone roads per mile	$2,000
Total original cost of improved roads	$537,696
Annual cost of repairs per mile on gravel roads 5 years old	$175
Miles of improved roads (gravel) built in 1905	29
First improved roads built	1893
Proportion of improved roads built since 1895 (per cent.)	75
Satisfaction of farmers with investment in improved roads	Good
Authority	H. W. Wacker, County Auditor

The general sources of road material in Jackson County are similar to those in Bartholomew, with the exception of the absence of

*For standard of comparison see p. 79.

limestone in the eastern part of Jackson. The gravel deposits of White River continue throughout the county, the gravel gradually becoming finer as the junction of Muscatatuck River with White River is approached. As a rule there is a greater deposit of silt above the gravel in this county than in Bartholomew. The Knobstone shales furnish a wider area of the red creek gravel than is the case in the latter county. There is only one limestone quarry in Jackson County—the Luedtke quarry in Carr Township. There is a small outcrop of the Goniatite limestone in the eastern part of the county, which might possibly be used for road purposes, although the formation is comparatively thin and the supply limited. Some townships are very well equipped with improved roads; others have less than a dozen miles each. Some limestone has been shipped in and used on roads, but that in only limited amount.

The total number of miles of improved roads in this county in October, 1905, was 480, of which only ten miles were rock roads. About 50 miles were being built or were soon to be built. The cost per mile of river gravel roads is about $1,500; of the red gravel, $700 or $800.

The following list shows the number of miles of improved road per township in October, 1905:

Driftwood	21.33
Grassy Fork	8.71
Brownstown	83.01
Washington	12.61
Jackson	68.96
Redding	44.07
Vernon	23.98
Hamilton	82.58
Carr	54.89
Owen	43.50
Salt Creek	75.35
Total	479.39

The pike from Seymour to Brownstown is built mainly of river gravel. About three miles of the Brownstown end is topped with red gravel. The part that is made wholly of river gravel or bank gravel has a loose surface, while the part which is topped with the red gravel has a smooth, even surface.

Gravel for the Seymour-Comiskey pike, in this county, was obtained from White River at Rockford. It was put on in 1893-94. This is not a smooth pike, the gravel being too fine to pack well, and a lot of loose material is always lying on top.

Philip Sweaney.—Southwest quarter of section 1 (5 N., 6 E.), Vernon Township. An outcrop of limestone and shale occurs here on the Muscatatuck River, and extends about five rods along the left bank of the stream. Ten rods above, on the same side of the stream, is a similar outcrop; also 80 rods farther down the stream the rock is exposed for eight or ten rods. The bed of the river cuts through about ten feet of New Albany shale and the limestone lies just above the shale.

Section at Sweaney's Ford.

		Feet.
1.	Soil	6
2.	Limestone, knobby, fine-grained, impure, easily breaking into small pieces along many natural joints	6
3.	Shale, black, hard, fissile, bituminous	6 to 10

In an 18-foot well on the Sweaney place, about 30 rods back from the river, the same limestone was struck. On the E. E. Foster farm, east half of section 2 (5 N., 6 E.), limestone above the shale was penetrated four or five feet. No attempt has been made to use this limestone on roads, though it would doubtless make a good road metal. Lying as it does in a region where other road material is scarce, it deserves careful investigation.

The pike from Brownstown to Medora is very poor. It lies along a sandy country, and the usual manner of applying gravel has not been suited to this kind of soil. Much of the way the road is a mushy mixture of sand and gravel two or three inches deep. A little better surface has in places been secured by using the red creek gravel, but the crust formed by this gravel is liable to be cut through and let the wheels sink through to the loose sand below.

Vallonia.—Part of the northeast quarter of section 29 (5 N., 4 E.), Driftwood Township. A gravel pit owned by the county lies in the edge of the town. It is about 100 yards in diameter and shows one to two feet of sandy soil, below which is six feet or more of gravel. This is one-fourth to one-half an inch in diameter and contains much sand.

John Mahan.—Southeast quarter of section 1 (4 N., 3 E.), Driftwood Township. Gravel is obtainable on this farm, and also on the farm of Henry Peters near by, part of the southeast quarter of section 12 (4 N., 3 E.).

Along the pike running northwest from Ewing to White River there is an old gravel pit, in which gravel is found within one foot of the surface. At the bridge are large gravel bars in the river, comprising some four or five acres.

W. Clayborn.—Northeast quarter of section 18 (5 N., 4 E.), Brownstown Township. The limit of available gravel lies about as far from the river as is the pit located on this land. Farther away from the river the gravel becomes more and more deeply overlain with the light-colored silt called here "white slash."

Henry Lehrman.—Northwest quarter of section 19 (5 N., 4 E.), Brownstown Township. A gravel pit is located about 40 rods east of the west line of Brownstown Township. This also is at about the limit of accessible gravel in this bottom. The pit has not been used for some years.

William Hunsucker.—Northwest quarter of section 9 (4 N., 3 E.), Carr Township. In a well dug near the house, which is situated at the foot of the Knobstone hills, shale was struck at a depth of 30 feet, but no gravel was found. Another well was dug some 15 rods farther out on the bottom, in which were found about 10 feet of whitish clay, 10 feet of "blue mud," and gravel. The gravel was penetrated eight feet. This shows that gravel may occur below the "white slash," contrary to the opinion held by some.

A. King.—Part of the northeast quarter of section 3 (4 N., 3 E.), Carr Township. A gravel pit 100 by 30 yards in area here shows two feet of soil and five feet of gravel, the latter being rather fine, averaging one-fourth of an inch in diameter.

J. C. Hinderlider.—Part of the southwest quarter of section 3 (4 N., 3 E.), Carr Township. Just north of King's pit is a pit of about the same dimensions, containing a similar quality of gravel. Material from these two pits was used on the new pike just completed in the vicinity. One of the owners states that gravel is found beneath the "white slash," and it is only a matter of increasing depth of the latter as the hills are approached that renders the gravel inaccessible. The pike made from the

gravel of these pits is quick to pack and appears to be of a superior quality.

Robert Eshom.—Southwest quarter of section 10 (4 N., 3 E.), Carr Township. About one mile of pike was made from a gravel pit on this farm. The gravel is very fine and does not pack readily. The inferiority of this material as compared with that from the King and Hinderlider pits is strongly noticeable where the two parts of the pike come together.

Along the road near Thomas Zollman's place, southeast quarter of section 8 (4 N., 3 E.), Carr Township, river gravel has been used. It is too fine and contains too little cementing material to pack well.

Near Sparksville there is an extensive area of bottom land, but the gravel is too deeply buried to be available. Considerable gravel is secured from bars in the river at the "bend."

The pike north from Sparksville follows up a ravine to the top of the hills. The metal used on this road was taken from creeks in the region. It consists of a sandy gravel of a reddish-brown color. There are many small geodes, in size from half an inch to three inches in diameter. The rest is largely sandy, iron oxide concretions.

The mixing of the red creek gravel with the river gravel has been tried in a small way in this township, but it is said to be not as good as the red gravel alone.

Albert Luedtke.—Part of the southwest quarter of section 11 (4 N., 2 E.), Carr Township. This place is noticeable as being one of the few where limestone occurs. A quarry has been operated here for many years. About 140,000 cubic feet have been removed.

Section at Luedtke's quarry.

		Feet.
1.	Soil	10
2.	Limestone, drab-colored, rather soft, containing much clay	8
3.	Limestone, gray oölitic, tough, moderately soft, massive	8
4.	Limestone, blue, harder and firmer than No. 3	4

No. 4 is used for monuments, while No. 3 is said to be equal to that of the Bedford quarries as a building stone. This limestone outcrop furnishes an opportunity for successful quarrying, but is so remotely situated that it has not been fairly developed.

Rock is taken from here for bridges, tombstones, etc. Only two miles of pike have been made from it, and that is in Lawrence County. Twenty acres would be available.

While the streams of the Knobstone region of Jackson County are liberally supplied with red gravel, that material is not inexhaustible. A road superintendent in the eastern part of Owen Township stated that his six teams had that day cleared about a mile of Butler Creek, and he could not get enough good gravel without hauling two or three miles.

Some sandstone, such as is found in these hills, has been used on the Clear Spring-Brownstown pike. This rock was broken up with hammers and thinly spread on the road, then was covered with red gravel. The piece of road so constructed is in fair condition, although the surface is not so compact as is usually the case with the red gravel roads. It is said that in a wet time this road becomes very rough. This is hardly a fair test of the efficiency of sandstone as a road metal. Doubtless with proper grading, with a thicker application of metal and with a liberal top coat of red gravel this rock would be found to be more serviceable than is now thought to be the case. However, it should never be used when other material is available.

At Shieldstown there is a large gravel bar in White River, owned by William Bikeman. Fresh material is brought in with every freshet.

Elizabeth Garvey. —Northwest quarter of section 35 (6 N., 4 E.), Hamilton Township. Here is located a gravel pit, from which was built, ten years ago, the pike running along the north side of sections 35 and 36 (6 N., 4 E.). The road has been repaired in many places, and is now in very good condition.

A wide extension of White River valley reaches beyond Surprise, in the western part of Hamilton Township. Gravel lies deep beneath "white slash" over much of this area, but it is usually struck in the making of wells on the bottom land.

The pikes of Salt Creek Township are made of the iron oxide gravel, and for the most part are in good condition. On Salt Creek gravel is abundant as far as Freetown. Below this it occurs in the branches, but not to any extent in the main stream. The road from Kurtz to Maumee has been thinly covered with a

poor quality of gravel taken from the creeks, and is now not much better than a dirt road. Red gravel is used on the Freetown-Cortland pike to within four miles of Cortland. From there on river gravel is used.

John Beatty.—Northeast corner of the northeast quarter of section 16 (6 N., 5 E.), Hamilton Township. A gravel pit is located half a mile south of Cortland. The gravel is about two feet below the surface, and has been removed to a depth of six feet. The material is rather fine, ranging from sand to gravel one-fourth of an inch in diameter. Two or three miles of road were made from this pit some years ago. Repairs are now being made from it.

William Shields.—East half of the southeast quarter of section 35 (7 N., 5 E.), Hamilton Township. A gravel pit 150 by 100 yards in area is located just east of the schoolhouse. It is owned by the county. There is soil to a depth of three and a half feet. Below this is four feet of gravel one-eighth to one-fourth inch in diameter. Several acres are available.

Fred Mellencamp.—Northeast quarter of section 2 (6 N., 5 E.). Hamilton Township. On this farm there is apparently a good place for a gravel pit, but none has been opened.

Harry Peters's Heirs.—East half of the southwest quarter of section 31 (7 N., 6 E.), Redding Township. North of Rockford, on this farm, gravel is obtainable from a small pit. The gravel is one-eighth to one-half an inch in diameter.

J. J. Rapp.—Part of the southeast quarter of section 32, and *John Hamilton*, southwest quarter of section 28 (7 N., 6 E.), Redding Township. Each of these farms has accessible gravel bars in White River.

Margaret Amick.—Southwest quarter of section 15 (7 N., 6 E.), Redding Township. About a mile and a half northwest of Reddington is located a gravel pit 100 by 100 yards in area. Five feet of soil overlies ten feet of gravel, one-fourth inch in diameter, with intervening layers of sand. This gravel has been used on roads, but is rather too fine to make a good surface. The pit is owned by the county.

From Reddington to Rockford, White River keeps close to the highland on the east. High sand dunes border the edge of the

upland and extend back one or two miles. To the east of these sand hills lies a rich, clay land, with considerable black soil.

Redding Township has practically all the roads improved. Most of the gravel used in this part of the county comes from bars in White River.

The pike running east from Brownstown is made of red gravel. It is smooth and solid and has been in use two years. The gravel came from a creek on the Swine and Henry Heller farms. It is above the average in size, being one-fourth inch to one inch in diameter.

A. Claybeaker.—Southeast quarter of section 8 (5 N., 5 E.), Brownstown Township. Much iron oxide gravel occurs in Horse Lick Creek, but funds are not sufficient to utilize it on the roads.

On the east line of Brownstown Township a line of pike was laid in the fall of 1904. River gravel was used. The road is in a very unsettled condition. The wagon wheels have cut deeply into the gravel and have pushed it aside rather than packed it into a solid bed.

A pike running on the north line of Washington Township was built 12 years ago from river gravel taken from a bar in White River just north of Rockford, near the P., C., C. & St. L. Railway. This pike is now well packed and has a smooth, solid surface.

"Bells Ford."—Northwest quarter of section 12 (6 N., 5 E.), Hamilton Township. A gravel bar in White River is located just above the Southern Indiana Railway bridge. Gravel has been used from this place for many pikes in the southeastern part of the county. The Seymour-Dudleytown pike is made of this gravel and it is now a good, solid road.

The White River bottom merges into the bottom of Grassy Fork southwest of Seymour over a scarcely perceptible divide. The main dividing line is about the middle of section 25 (6 N., 5 E.) and section 30 (6 N., 6 E.). This region appears to be an old valley of White River leading into the valley of the Muscatatuck through the present valley of Grassy Fork Creek. On the southwest quarter of section 32 (6 N., 6 E.), two and a half miles south of Seymour, a well was dug which showed 45 feet of clay, 10 feet of sand, and then gravel. The top of this well was on a slight

eminence, 10 or 15 feet above the surrounding level. A deep well drilled on the farm of William Casting, southwest quarter of section 35 (6 N., 5 E.), in the southwestern part of Jackson Township, was described from memory by one of the drillers as follows:

Section of well on farm of William Casting.

		Feet.
1.	Clay and sand	17
2.	"Soapstone"	150
3.	Black shale	40
4.	Whitish-gray rock, changing color frequently to black and reddish.	53

"In this well a kind of ore was found at a depth of 150 feet. This was a hard, brittle, lead-colored, shiny substance."

The "soapstone" here described is probably the Knobstone shale formation. The "ore" found near the bottom was evidently iron pyrites.

About three and a half miles northeast of the Casting well another well was drilled by the same parties—Wieneke Bros.—on the farm of George Whitsund, section 35 (6 N., 5 E.), Jackson Township, which disclosed the following section:

Section of well on land of George Whitsund.

		Feet.
1.	Clay and sand, alternate layers, with "blue muck" at 50 feet	53
2.	Black "clay," containing moss and wood at bottom	40
3.	"Soapstone"	50
4.	Rock, whitish-gray	5
5.	Rock, reddish	2

"At 150 feet the well was left over Sunday. By Monday morning water had risen to within eight feet of the top, and gas was noticeable."

The low, flat land lying southwest of Seymour, now well drained and never overflowed by the river, was formerly—in 1810—a swamp, with water standing two feet deep throughout most of the summer.

August Wieneke.—Southeast quarter of section 7 (5 N., 6 E.), Washington Township. Two miles north of Dudleytown, on the Dudleytown-Seymour pike, there is a high glacial hill called Chestnut ridge. The highest point on this hill is at the base of a walnut tree a short distance south of the church, which stands 10 or 15 rods north of Mr. Wieneke's house. This elevation is 365 feet above the Ohio River. Near the summit of this hill Mr. Wieneke has a well which, at a depth of 78 feet, reaches into gravel.

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August Wieneke.—Southeast quarter of section 7 (5 N., 6 E.), Washington Township. Two miles north of Dudleytown, on the Dudleytown-Seymour pike, there is a high glacial hill called Chestnut ridge. The highest point on this hill is at the base of a walnut tree a short distance south of the church, which stands 10 or 15 rods north of Mr. Wieneke's house. This elevation is 365 feet above the Ohio River. Near the summit of this hill Mr. Wieneke has a well which, at a depth of 78 feet, reaches into gravel.

Vernon Township roads are built mainly of gravel shipped from without the township, mostly from the William Shields gravel bar in White River, about a quarter of a mile above the bridge of the P., C., C. & St. L. Railway. Some of the bottom roads are made of rock, which was shipped from Cementville, Clark County.

Grassy Fork Township has only six or seven miles of pike. This is made of rock and is included in the Crothersville-Brownstown pike. This rock pike is in poor condition, being rough and much covered with loose material.

A short range of Knobstone hills, lying across the eastern part of Brownstown Township and extending into Driftwood Township, is the source of a red gravel which supplies many of the roads in that region. The Muscatatuck River has no gravel bars of consequence.

SCOTT COUNTY.

Area in square miles	190
Population in 1900	8,307
Miles of public roads	400
Miles of improved roads	116.36
Percentage of roads improved	29
Miles improved with gravel	37.8
Miles improved with crushed stone	29.14
Miles improved with black shale*	49.42
Average original cost of gravel roads per mile	$1,047
Average original cost of stone roads per mile	$1,198
Average original cost of shale roads per mile	$1,087
Total original cost of improved roads	$128,214
Annual cost of repairs per mile on gravel and shale roads 5 years old	$35
Annual cost of repairs per mile on stone roads 5 years old	$45
Miles of improved roads (shale and gravel) built in 1905	3
Miles of improved roads (gravel) contracted for 1906	6.9
First improved roads built	1898
Satisfaction of farmers with investment in improved roads	Good
Authority	Frank Gardner, County Auditor

*Some of our roads are built of black shale or "slate." The most of these shale roads have a gravel covering of from two to five inches. It costs more to repair the stone roads than it does to repair the gravel and shale roads. One reason for this is that the first stone roads were not built strong enough and are subjected to the most travel. None of our roads have enough repairs put on them.—F. G.

From the above table it will be seen that Scott County is fairly well provided with improved roads. In this county we find for the first time the New Albany black shale being used extensively

as a road metal. Rock and red gravel are also used. Most of the material is provided in the county; some of the rock is shipped in. The roads are built largely by contractors, who furnish their own material. The county does not own a crusher. The best roads of the county are made from red creek gravel from the Knobstone area. The New Albany black shale makes a very smooth pike, but it is liable to be cut up by heavy traffic. The rock pikes are very poorly constructed.

Lexington Township has 33.74 miles of pike. Johnson and Jennings together have 34.13 miles, each having about an equal amount. Finley and Vienna townships have 48.95 miles, about half the number in each. The first roads were built in 1898 in Finley and Vienna townships.

Running east from the north side of the court house square at Scottsburg is a limestone pike, the Scottsburg-Lexington pike, built about seven years ago. The pike is in poor condition, being uneven in surface and having much loose material on top, which, when thoroughly wet, remains muddy for several days.

Half a mile east of Scottsburg a pike runs north from the Scottsburg-Lexington pike. For about a mile the material is limestone. This was built two years ago and is in only fair condition. The roadbed is too low, being on a level with or below the dirt grade on each side, and traffic has cut into the surface. About a mile north of Stuckers Fork the limestone macadam is succeeded by shale. Just after a protracted rain this shale pike was much smoother and drier than the rock pike. In respect to smoothness and freedom from loose material this piece of shale pike surpasses most of the gravel pikes and many of the rock pikes in this area.

The Frankfort pike is made largely of shale, and for the most part is smooth and free from loose material on top.

The pike running north from near Woostertown was made in 1900. The shale was laid down in rather large pieces and was covered with dirt. The dirt kept the surface from the air until the road had become solidly packed. Where not so covered, shale roads are less solid, owing to the disintegration or "slacking" of the material due to the action of the weather. After the shale is once packed the wear and weathering are confined to the surface, the large fragments below furnishing a solidity of bed.

Joseph Smith.—Southeast quarter of section 10 (3 N., 7 E.), Jefferson Township. A shale quarry was here opened for building the neighboring pike.

Section of Smith quarry.

		Feet.
1.	Soil	2 to 3
2.	Shale, hard, black	4 to 8

The quarry is situated well up to the general level of the surrounding upland. Another outcrop of shale occurs near the road, about half a mile northeast of the Smith place. Other places along this road show outcrops of shale.

In Johnson Township shale outcrops may be found as follows:

Andrew Arbuckle.—Southwest quarter of section 25 (4 N., 7 E.).

Cynthia Townsel.—Northwest quarter of section 25 (4 N., 7 E.).

John Tobias.—Northwest quarter of section 24 (4 N., 7 E.).

On the dirt road running east and west through the center of sections 14, 15 and 16 (4 N., 7 E.), in the northern part of Jennings and Johnson townships, several outcrops of the black shale are noticeable in the small valleys crossing the road.

The pike along the north line of section 17 and the east half of section 18 (4 N., 7 E.), was made in 1905. It is well packed already, but in some places the wagon wheels have cut through the macadam.

On the Muscatatuck River at many places shale underlies the stream and outcrops on the bank. About a quarter of a mile south of the mouth of White Oak Branch is a shale quarry from which was made part of the pike running from the middle of section 18 (4 N., 7 E.), to the river. On the south half of section 13 (4 N., 6 E.), is another outcrop. This piece of pike, built some six years ago, is in poor repair. Heavy traffic has cut into the road and almost destroyed it.

Shale quarries in Jennings Township are located on the following farms:

L. A. Truelock.—Northwest quarter of section 31 (4 N., 7 E.).

J. S. Morgan.—Northeast quarter of section 30 (3 N., 6 E.).

Melinda Williams.—Southeast quarter of section 36 (4 N., 6 E.).

The pike running south from the middle of section 18 (4 N., 7 E.), to Stuckers Fork has been badly cut by heavy teaming when the ground was water-soaked.

The Oard Spring pike, running through Jennings Township a mile west of the east line, is in good order. This pike has not been subjected to excessive traffic during a wet time, and it remains in a fairly smooth condition.

In almost any part of Jennings and Johnson townships shale may be obtained in the small valleys at a depth of six feet or less. The creeks have wide valleys in which no shale is found near the surface as a rule. These townships are poorly provided with good roads. The few shale pikes that they have are very serviceable as long as heavy traffic is kept off in wet weather.

The Scottsburg-Marshfield pike, running from Scottsburg to Stuckers Fork, is made of stone. The west end of it is in fair condition, but is in need of repairs. The last mile or so leading into Scottsburg is covered with two or three inches of dirt. In time of rains this is wholly loosened up and mixed into mud.

The pike from Scottsburg to Little York is very rough for the first two miles or so. The surface is channeled with two or three wheel ruts. The top is low and without slope. The whole road needs to be made over; the stone to be placed on a higher grade and the top to be coated with gravel or rock screenings. Next west of this is a mile of stone pike which is in very good condition. This difference is due to the better grading of the road and the greater care taken in putting on the rock.

Most of the pikes in the southwestern part of the county are built of the red creek gravel, which is there abundant. They all are of excellent quality and are not badly affected by wet weather.

From Vienna to Lexington the road is made of stone taken from the English quarry at Lexington. It is not very well constructed. The rock used is of large size and no screenings or gravel have been put on top. In some places dirt has been applied; in others black shale has been put on top. This method leaves a rough road and often a muddy or dusty one at the same time. It was built three years ago. On Kimberlin Creek the New Albany black shale is seen outcropping on the sides of the valley. At several other places on this road shale crops out on the sides of the val-

levs. There seems to be about ten feet of drift on top of the shale, and in general the present drainage follows the preglacial drainage system.

William E. English.—Northwest quarter of section 34 (3 N., 8 E.), Lexington Township. A limestone quarry 30 to 100 yards in area is located north of Lexington on Stuckers Fork.

Section of quarry on land of W. E. English.

		Feet.
1.	Soil and New Albany black shale	2 to 4
2.	Limestone, hard, blue-gray, fossiliferous, clayey, thick-bedded	10

This limestone crops out along the creek for a mile or more in this vicinity. The bottom of the overlying shale is about 40 feet above the creek. Twenty or more acres are available. Samples of this stone were secured and sent to the U. S. Road Testing Laboratory at Washington, with the following results:

*Results of Physical Tests of Devonian Limestone from land of W. E. English.**

Specific gravity	2.65	French coefficient of wear	12.3
Weight per cu. ft. (lbs.)	165	Hardness	2.7
Water absorbed per cu. ft. (lbs.)	2.27	Toughness	9
Per cent. of wear	3.3	Cementing value—Dry	28
		Wet	103

"A soft but tough limestone with a good resistance to wear and excellent cementing value. Suited to highway and country-road traffic."—Page.

An analysis of the sample, made at the same laboratory, showed as follows:

Analysis of Devonian Limestone from land of W. E. English.

	Per cent.
Alumina (Al_2O_3)	.70
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	44.85
Magnesia (MgO)	5.43
Phosphoric acid (P_2O_5)	.25
Insoluble in hydrochloric acid	7.39
Loss on ignition	40.85
Total	99.72

Joseph Amos.—Southwest quarter of section 31 (3 N., 8 E.), Lexington Township. Rock was taken from this farm for part of

*For standard of comparison see p. 79.

the Lexington-Madison pike. It is essentially the same type of outcrop and the same formation as the English rock.

The Lexington-Scottsburg pike is made of stone. Some parts are covered with dirt and some with river gravel. Where the gravel is used on top the road is moderately smooth; where dirt is used the surface is rough, with many ruts and mud holes.

The Scottsburg-Vienna pike was one of the earliest built in the county. It is made of rock, but the material was applied so thinly and so little grading was done that it is unbearably rough, and, in rainy seasons, exceedingly muddy. The size of the rock is three to four inches in diameter.

CLARK COUUTY.

Area in square miles	375
Population in 1900	31,835
Miles of public roads	600
Miles of improved roads	171
Percentage of roads improved	28.5
Miles improved with gravel	35
Miles improved with crushed stone	136
Average original cost of gravel roads per mile	$808
Average original cost of stone roads per mile	$993
Total original cost of improved roads*	$138,546
Annual cost of repairs per mile on gravel roads 5 years old	$50
Annual cost of repairs per mile on stone roads 5 years old	$57
Miles of improved road (gravel) built in 1905	2
Miles of improved road (stone) built in 1905	3
First improved roads built	1885
Miles of improved roads built since 1895	66
Satisfaction of farmers with investment in improved roads	Good
Authority	V. W. Lyon, C. E.

*Cost of toll roads not included.

As seen from the above table, there are 171 miles of improved roads in Clark County, of which 25 miles are toll pikes. One pike, 3.74 miles long, formerly a toll pike, under the name of the Jeffersonville, Cementville and Silver Creek pike, has recently been bought by the county for $3,500. Three pikes are yet operated as toll roads, viz., the Jeffersonville-Utica pike, eight miles; the Jeffersonville-Charlestown pike, 12 miles, and the Utica-Charlestown pike, 5 miles long. The owners of the first-named recently refused to sell their road to the county at $1,243 per mile. Considerable improvement has been done by farmers work-

ing conjointly, with some assistance from the county, but on the whole the county is behindhand in the good roads movement. Some townships have not a single mile of improved road, though road material lies around in abundance. The western part of the county is in the Knobstone shale district, which furnishes a good iron oxide gravel. The central part has both the New Albany black shale and limestone; the eastern part has limestone and river gravel.

David M. Schuler.—Grant 271, Monroe Township. An outcrop of shale by the road, on a branch of Millers Creek, is 10 to 12 feet thick. An area 20 by 20 yards was removed three years ago for building two and a half miles of pike. This pike runs from one mile south of the north line of the county to near Henryville. Shale was put on and was covered with the red gravel. It is a smooth, solid road. The cost of repairing this and two and a half miles more is this year $200. A pike similar in construction runs five miles northeast of Henryville. Part of this is made wholly of shale.

From the eastern end of this pike to the east side of Washington Township there is no pike. Oregon, Washington and Owen townships have not a rod of improved road, while the greater part of Charlestown Township is also without such roads. Black shale underlies the region from Henryville to Newmarket and outcrops on every hillside in that region.

James Cortner.—Grant 246, Oregon Township. On this farm there is a shale quarry, owned by the township. A section ten feet thick is exposed on the side of a small valley and is overlain with one to three feet of soil. Material is being taken from here and spread thinly on some parts of the most-traveled roads, but no thorough pike-making is in progress.

At Newmarket, limestone of the Hamilton formation comes to the surface. It outcrops all along Fourteen-Mile Creek, and, at this place, appears on the hillsides 60 feet above the creek. The following locations along the Newmarket-New Washington road have outcrops of limestone:

Charles Smith.—At Newmarket.

Sarah Bower.—In the same neighborhood.

Jake Bottorff.—Grant 179.

Emanuel Clapp.—Grant 197, and Grant 198.

From New Washington to Bethlehem Township limestone crops out in every valley. At the west line of Bethlehem Township begins a rock pike which extends to the village of Bethlehem, five and a half miles. This pike was built about three years ago from various outcrops of limestone along the route. It is in fairly good condition, but needs a top layer of fine stone. Heavy traffic has cut into the top, leaving ruts two or three inches deep. In some places the pike has been thrust to one side of the highway, leaving room for a dirt road on the other side. In a dry time most of the travel is on the dirt road, which thereby becomes thickly coated with dust. When heavy rains come this fine material is washed down hill and is spread over the rock road to a depth of three to six inches. Rock for this pike was quarried at the following places:

Camp Creek.—Where the pike ends.

G. D. Watkins.—Farm.

S. A. Stansbury.—Part of the southeast quarter of section 36 (2 N., 10 E.).

G. D. Giltner.—Northwest quarter of section 7 (2 N., 10 E.), about one mile from Bethlehem.

This last quarry is at the brow of the bluffs overlooking the Ohio River.

Section of quarry on farm of G. D. Giltner.

	Feet.
1. Soil	2
2. Limestone hard, fine-grained thick-bedded	20

The lower part of No. 2 breaks easily into slabs and bears a streaked appearance, being bluish-green and pink in hue.

William Ross.—Northeast quarter of section 8 (1 N., 10 E.), Bethlehem Township. About a quarter of a mile west of Bethlehem a gravel pit is located in a high terrace of the Ohio valley, which continues southwest for about three miles, with a width of 40 to 60 rods. The lower terrace extends about a mile north of Bethlehem, where the river comes close to the rocky bluffs. Not much gravel has been removed, but the amount available is unlimited. The soil on top is from two to four feet deep. In building cisterns on the lower terrace gravel is struck a few feet below the surface. There is much gravel obtainable along the river's

edge. From Bethlehem down the river the bottom land continues to the mouth of Camp Creek. There is no pike along the bottom, although gravel underlies the whole surface at a depth of a few feet.

A road leading from the Ohio valley up the hill toward Solon is very steep, narrow and poorly constructed. It was built at an expense to the county of $400, and is absolutely impassable during much of the winter season.

From the southwest corner of Bethlehem Township to Fourteen-Mile Creek the Bethlehem-Charlestown road runs along a high and generally level country. Rock is accessible to any part, with a hauling distance of not over one mile. Outcrops of limestone are noticeable at the following points along the road:

Southwest of Solon.—A quarter of a mile.

Joseph Taggart Farm.—Grant 81, 0—6 feet stripping necessary, a 16-foot ledge being exposed for 20 rods or more along the valley. From the southeast side of Grant 99 a pike leads into Charlestown. This is made of broken rock six to ten inches in diameter. It has apparently had some finer rock on top, but this being largely washed off, the larger rocks are exposed.

At Charlestown several outcrops of limestone occur. About half a mile northwest of town the road runs over the rocky bed of Fallen Run. Within the town limits the banks of this stream are filled with limestone. At this point a sample was secured for testing. The exposure is 15 feet high, with from none to six feet of soil on top. An acre or more could be here quarried.

*Results of Physical Tests of Devonian Limestone from quarry near Charlestown.**

Specific gravity	2.6	French coefficient of wear	7.1
Weight per cu. ft. (lbs.)	162.2	Hardness	3.5
Water absorbed per cu. ft. (lbs.)	1.41	Toughness	8
Per cent. of wear	5.6	Cementing value—Dry	17
		Wet	52

"A rather soft but fairly tough rock with a fair resistance to wear and a good cementing value. Suited for country-road and highway traffic."—Page.

A chemical analysis of the stone, made at the same laboratory, showed the following results:

*For standard of comparison see p. 79.

Analysis of Devonian Limestone from quarry near Charlestown.

	Per cent.
Alumina (Al_2O_3)	.25
Iron oxide (Fe_2O_3)	.25
Lime (CaO)	53.45
Magnesia (MgO)	.80
Insoluble in hydrochloric acid	3.22
Loss on ignition	41.98
Total	99.95

One mile northwest of Charlestown, on the Memphis road, is the easternmost outcrop of the black shale in this part of the township. From here to Memphis the shale appears in several places.

Edgar Haas.—Grant 153, Charlestown Township. Limestone crops out east and west of the house. One to two acres are available with little stripping.

James Mathes.—Grant 170, Union Township. There is a limestone outcrop 20 feet above Sinking Fork on the west side, in the road.

E. L. Gurnsey.—Grant 186, Union Township. On this place is a hill about 100 feet high, consisting wholly of black shale. Any amount of material would be available.

From Memphis a pike built of crushed stone and covered with red gravel extends southeast for one mile. Some shale has been used on the road from a deposit near the end of this pike one or two miles toward Charlestown. Both the rock pike and the portion of shale road are in good condition. This pike was built in 1903. Between Charlestown and Sellersburg there are many outcrops of limestone.

Silver Creek Township is well supplied with limestone. This township is in the center of the cement manufacturing industry of the county, and is well supplied with pikes, limestone being the prevailing metal used. The Sellersburg-Watson pike has been built piece by piece by the farmers. It is not uniform in condition. Some parts are smooth, some are rough, while some are low and muddy.

North from Sellersburg toward Memphis and southwest through Hamburg to the county line the pike is constructed of crushed limestone put on six inches deep, and covered with iron oxide gravel three inches deep. This combination gives a more solid

road than does the red gravel alone, but it is not quite so smooth, since the gravel wears up and is washed away, leaving the rock exposed. The gravel coating apparently has kept the rock from being cut into ruts before it has become thoroughly packed, and the top presents a rounder surface on that account.

In Cass and Wood townships the farmers have used the red gravel from the Knobstone hills and have worked up the roads until they are in a commendable condition. While the amount of gravel put on is insufficient to stand heavy traffic, yet for much of the time they are far superior to dirt roads. These townships are wholly within the Knobstone area, and enough of the red gravel can be obtained for the principal roads.

A large part of Jeffersonville Township is a low plain cut by the stream valleys, which lie 15 to 25 feet lower. A part is underlain by limestone, and a part by gravel. The approximate boundary of the Ohio River deposits is shown on the map. It is uncertain how far up the valley of Silver Creek the gravel deposits extend, but it is probable that the limit is not farther north than a line running west from the B. L. Burtt place.

William Ingraham.—Grant 8, Jeffersonville Township. A gravel pit near Jeffersonville comprises about six acres. This pit is in the edge of a high river terrace, which extends from Utica to this point.

Section of Ingraham's gravel pit.

		Feet.
1.	Soil, silt	16
2.	Sand	4
3.	Gravel, ¼ to ½ inches in diameter	8

Much of this gravel has been used on the pikes in the neighborhood and for concrete work. Ten acres more can be readily utilized.

B. L. Burtt.—Grant 9, Jeffersonville Township. About a mile north of Jeffersonville a new quarry is being opened up, but rock has been removed from other parts of the farm for several years. This quarry is more easily accessible to Jeffersonville than any other. Rock from this farm has frequently been used in making pike for the past four or five years.

Section of the Burtt quarry.

		Feet.
1.	Soil and rotten limestone	6
2.	Limestone, soft (hydraulic)	8
3.	Limestone, hard, coarse-grained, containing many fossils	6

Ten acres or more are available.

The results of a test of a sample from stratum No. 3 are as follows:

*Results of Physical Tests of Devonian Limestone from quarry of B. L. Burtt.**

Specific gravity	2.65	French coefficient of wear	11.7
Weight per cu. ft. (lbs.)	165	Hardness	3
Water absorbed per cu. ft. (lbs.)	1.23	Toughness	7
Per cent. of wear	3.4	Cementing value—Dry	31
		Wet	91

"A soft limestone of fair toughness and resistance to wear, and a good cementing value. Suitable for light traffic roads or as a binder."—Page.

The Jeffersonville-Hamburg pike was built many years ago. It is made of large, flat pieces of rock set on edge crosswise to the road. This makes a very solid foundation for a road, but without a covering of finer rock it is exceedingly rough, so that, when possible, most of the travel is shifted to a dirt road at one side.

This pike is about on the western edge of the limestone outcrop, of the Hamilton formation, while a line drawn from Hamburg to Memphis would leave practically all the outcrops of this formation to the east. From Memphis the edge of the outcrop swings toward the east and passes about a mile west of Newmarket. Thence it passes toward Lexington. It may be said that all that portion of Clark County lying southeast of this line has an abundance of limestone within easy hauling distance of any road desired to be piked. To the northwest of this line the county is well supplied with shale or with gravel.

The Jeffersonville-Charlestown pike was built 50 years ago. It is constructed of large pieces of limestone set on edge and packed closely together. It is now covered in some places with crushed stone. While some parts are comparatively smooth, there are many low places 10 to 15 rods long where water stands after rains. It is not well graded, the ditches being sometimes filled with mud. Steps are being taken to put it in repair.

*For standard of comparison see p. 79.

J. B. Wilson.—Northwest corner of Grant 4, Jeffersonville Township. On this farm a well was dug which disclosed gravel at a depth of 12 feet.

About a mile east of this place, some years ago, gravel was taken from the farm of William Gilmore, Grant 5, Jeffersonville Township. This region is within the Ohio River deposit which extends, as shown on the map, about 2 miles from the river, narrowing to a few rods just east of Utica.

About a mile west of Jeffersonville there is an outcrop of gravel near the base of the terrace. The gravel lies 15 feet deep on top of the Jeffersonville limestone, that forms the lower bank of the river at this place. Above the gravel the silt deposit reaches 15 or 20 feet.

Edward Howard, "Arctic Springs."—Grant 3, Jeffersonville Township. Gravel crops out of the river bank 15 feet above the water, with 12 feet of silt on top, and is distributed along the river's edge for a quarter of a mile or more. No farther outcrop was noted until within the vicinity of Utica, where a limited amount appears along the river. This gravel is not valued for pike purposes here, as it shifts about on top of the road, gradually working out to the sides by the action of traffic upon it.

William Hobson.—Grant 7, Utica Township. A limestone outcrop here is about the southern limit of limestone near the river. From Utica to the Jefferson County line, limestone appears in the steep bluffs overlooking the Ohio River.

George Zinck.—Grant 17, Utica Township. Gravel extends along the river about 1½ miles north of Utica. In this vicinity a rock road 2½ miles long was made and kept in repair for many years by a public spirited individual, Mr. William Goodwin. This case of unusual interest in public roads deserves the praise of every fair minded citizen in the county. Since the departure of Mr. Goodwin the road has not been kept in repair.

Mary E. Work.—Grant 11, Utica Township. Gravel is exposed where a small run cuts through the high terrace. Eighteen feet of silt rests on top of 8 feet of moderately coarse gravel. At the George Zinck place the river bottom has a width of about ¼ mile.

James Steelman.—Grant 41, Utica Township. Gravel borders the river from here down for about 3 miles. It was struck in a

well on the second terrace at a depth of 20 feet and was penetrated more than 20 feet to below the level of the water in the river. Above the terrace, about 20 rods west of Mr. Steelman's place, is a small strip of the high terrace. The second terrace runs about ½ mile above the Steelman place. From there on to the mouth of Bull Creek the river keeps close to the rocky bluffs. At the mouth of Bull Creek the bottom widens to ¼ mile or more and extends along the river for about 1 mile. Gravel may be found along the river's edge here. From this point to the mouth of Camp Creek the river again keeps near the bluffs.

FLOYD COUNTY.

Area in square miles	150
Population in 1900	30,118
Miles of public road	350
Miles of improved road*	126
Percentage of roads improved	36
Miles improved with gravel	90
Miles improved with crushed stone	36
Average original cost of gravel roads per mile	$400
Average original cost of stone roads per mile	$1,000
Total original cost of improved roads**	$42,000
Miles of improved roads (gravel) built in 1905	40
Miles of improved roads (stone) built in 1905	2
First improved roads built	1900
Satisfaction of farmers with investment in improved roads	Good
Authority	Thos. Hanlon, County Auditor

*Including 30 miles of toll road.
**Not including cost of toll roads.

Floyd County lies mostly in the Knobstone belt and most of the material used for roads is the iron-oxide sandstone gravel that collects in the creek beds among the Knobstone hills. The western part of the county, however, has an abundance of limestone belonging to both the Bedford and Mitchell formations, while the impure limestone of the Harrodsburg formation covers the higher parts of the hills in the central part of the county. Much of the gravel of the western part is of the cherty Mitchell limestone variety. The New Albany black shale crops out along Silver Creek and on some parts of the Ohio River bank in the southeastern part of the county. This shale is not used as a road

metal in Floyd County. The Ohio River furnishes gravel such as is usually found in bars along that stream. No gravel pits have been opened, as the terrace gravel lies too deep below the surface to be available. At New Albany gravel is struck, in digging wells, at 40 to 45 feet on the high terrace on which the main part of the city is built. On the second terrace, 40 feet above the river, gravel was struck in a well by the flour mill at 30 feet, and was penetrated 30 feet when shale was encountered. The upper terrace deposit of gravel does not extend far north of the city, probably 1 mile from the river. The second terrace is about 15 rods wide.

The principal pikes of Floyd County are the New Albany-Bridgeport pike, running along the Ohio River; the Paoli pike, running from New Albany through this county and beyond to Paoli, Orange County, and the New Albany-Corydon pike, running westward from New Albany and leaving the county near the headwaters of Little Indian Creek.

The Paoli pike bears the distinction of being the oldest pike in the State.* It was graded and macadamized as far as Paoli in 1839, and in 1852 a plank road was built over the macadam. This plank road did not last long, being easily affected by traffic and weather. The stone road was made by placing flat pieces of limestone, 6 to 12 inches in diameter, on edge, generally crosswise to the direction of the road. These stones still remain as the foundation of the pike. For most of the distance a top of crushed stone has been applied. From Galena to Greenville red gravel is the top coating. This pike is at present in very good condition, the grades being gentle and the surface smooth and solid. Repairs are well kept up. Several stage lines run between the important towns on the route, and there is generally a heavy traffic. This remains a toll pike. Rock for the repair of this pike is secured at several places along the route.

The Bridgeport pike also has a very great traffic. It is the principal outlet from a wide farming region extending to the southern part of Harrison County. The pike, being constructed of river gravel, does not have a very firm top, owing to the lack of cementing material. The constant wear has left many chuck-holes, and the work of repairing has not kept up with the need of repair.

*For an account of the building of this pike see p. 33 of this report.

The New Albany end of the New Albany-Corydon pike was begun in 1850. From then on until 1854 work was continued, when the pike had reached to within five miles of Corydon. The road at first was made of plank, and the name of the company is still the "New Albany, Lanesville and Corydon Plank Road Company." As was the case with the Paoli pike, the planks soon gave place to gravel or rock. The part in Floyd County is made of rock. The portion from the west county line to Edwardsville is in fair condition, but from Edwardsville to New Albany the pike is in need of repairs.

The Cherry Street pike almost parallels the Paoli pike as far as Greenville. This pike is made largely of rock covered with red gravel from the creeks. In some places simply loose soil has been applied to the top. Much of this pike is not equal in smoothness to some of the red gravel roads built by the farmers in other parts of the county.

Numerous other improved roads traverse the county. These are generally made of the red gravel and are remarkable for their smoothness and firmness.

The total number of miles of improved road in Floyd County is 126. There are 10 miles of river gravel pike and 30 miles of rock (toll) pike. The rest is principally of the iron-oxide sandstone, or red creek gravel.

Owen Taggart.—Northwest quarter of section 10 (3 S., 6 E.), New Albany Township. On this farm Mr. Taggart found two or three feet of gravel below 20 feet of sand. This was near the hills. At another place, nearer the river, a well sunk for a schoolhouse was dug 30 feet and shale was struck without encountering any gravel. There seems to be very little gravel in the bottom land here, and that is at a considerable depth. A small amount of gravel occurs along the edge of the river, about a mile below New Albany.

Thomas Hanlon.—Southwest quarter of section 15 (3 S., 6 E.), New Albany Township. Gravel is noticeable along the river at this point.

Dr. William Moore.—Southwest quarter of section 28 (3 S., 6 E.), Franklin Township. From this farm house a gravel bar extends down the river for about three miles. It is exposed only

when the river is very low. The gravel is one-fourth of an inch to three inches in diameter, about 30 per cent. of the material being sand. This is one of the sources of gravel used on the Bridgeport pike.

Victor Knadler.—Southeast quarter of section 31 (3 S., 6 E.), Franklin Township. Gravel crops out of the river bank 12 to 15 feet above low water. In size it runs from one-fourth of an inch to three inches, with some stones six to ten inches in diameter. The top of the river bank and bottom land is about 25 feet above the gravel outcrops. Material is hauled from this place to repair the pike.

Edwardsville Limestone Quarry.—West half of the northeast quarter of section 1 (3 S., 5 E.), Georgetown Township. This quarry belongs to the New Albany, Lanesville and Corydon Plank Road Company, and is 50 by 150 yards in area and 20 feet deep. Four to six feet of soil lie on top. The rock is mainly of the Bedford oölitic formation. This is the principal source of the rock used on the New Albany-Corydon pike, about ten miles of the pike having been made from it. The quarry has been worked 45 years. Samples from this quarry were tested at the Road Laboratory at Washington, with the following results:

*Results of Physical Tests of Bedford Oölitic Limestone from quarry near Edwardsville.**

Specific gravity	2.65	French coefficient of wear.	9
Weight per cu. ft. (lbs.)	165	Hardness	4.6
Water absorbed per cu. ft. (lbs.)	1.32	Toughness	9
Per cent. of wear	4.4	Cementing value Dry	25
		Wet	114

"A soft but fairly tough limestone with a rather low resistance to wear, which develops an excellent cementing value. Suitable for all but very heavy traffic and as a binding material."—Page.

*For standard of comparison see p. 79.

HARRISON COUNTY.

Area in square miles	470
Population in 1900	21,702
Miles of public road	675
Miles of improved road*	55
Percentage of roads improved	8.1
Miles improved with gravel (toll road)	11
Miles improved with crushed stone	44
Average original cost of stone roads per mile	$1,800
Total original cost of improved roads	$64,800
Annual cost of repairs per mile on stone roads 5 years old	$60
Miles of improved road (stone) contracted for 1906	23
First free improved roads built	1898
Satisfaction of farmers with investment in improved roads	Good
Authority	Frank E. Watson, County Auditor

*Includes 19 miles of toll road, owned by private corporations. The cost of this toll road is not included in the total original cost of improved roads.

Harrison County is a little behind in the good roads movement. With an area of about 470 square miles, there are less than 40 miles of free improved roads. Jackson, Spencer, Scott, Webster, Boone and Taylor townships are without a single mile of pike. The ordinary dirt roads here are no better than are those in other counties and pikes are needed. The fall of 1905 may mark the beginning of a revival of interest in road-making. Contracts were then let for ten pikes, each about two miles in length, to be built on the dirt roads leading out of Corydon. This should be a stimulus to the townships lying adjacent to work for an extension of those pikes into their respective townships. The following is the number of miles per township, date of construction and cost per mile of the roads already improved:

	Miles.	*Year.*	*Cost per Mile*
Posey	7	1895	$1,341
Posey	3	1901	1,266
Heth	7	1901	1,935
Washington	4½	1901	1,925
Harrison	7	1902	2,410
Blue River	8	1902	1,660
To be constructed	23	1906	1,086

Harrison County is very well supplied with limestone, which, in most parts, is easily accessible. The low cost of the rock pikes already constructed shows that the cost of obtaining rock is below what it is in many counties. Gravel may be had from the

Ohio River at many places, but this would naturally be little used, where rock is so abundant. Many of the creeks have a plentiful supply of gravel, usually the chert-limestone variety from the Mitchell limestone. This makes a peculiarly smooth, solid road. In Taylor Township a surprising deposit of chert and sandstone gravel was found as a talus at the foot of some of the rocky hills bordering the Ohio River valley. The prevailing surface limestone is of the Mitchell formation, although the underlying Bedford limestone is in many places found on the sides of the valleys. The surface of the county being much marked by sinkholes, the roads are often necessarily hilly.

At Bridgeport the river bottom narrows to about 20 rods in width, and continues that width for some two miles.

J. V. Bauer.—Section 24 (4 S., 5 E.), Posey Township, Bauer's Landing. Gravel crops out of the river bank about 15 feet above low water and extends to the water's edge. In size it is one-fourth of an inch to three inches in diameter, some stone being six to ten inches in diameter. The river bottom is here about 15 rods in width. Limestone is plentiful in the bluffs overlooking the river. Gravel continues along the river, more or less abundantly down to the McHarry farm.

Frank McHarry.—Southeast quarter of section 1 (5 S., 5 E.), Posey Township. A gravel bar on this place is said by river men to be the best bar between Louisville and Evansville. Some gravel is taken from here to repair roads.

Ellen Stewart.—East part of section 1 (5 S., 5 E.), Posey Township. A gravel bar adjoins that on the McHarry place, the combined length being about 60 rods, with an average width of four rods. It extends from low water to about 15 feet above. The gravel is the common size, with no large boulders. The bottom land at this point is 100 rods wide.

Bruckle.—Section 12; Stubblefield, section 13, and Reeves, section 24 (4 S., 5 E.), Posey Township. These adjoining farms are skirted with gravel, which crops out about 15 feet above the river's edge at low water and covers the intervening beach. On the river bank a small ravine cuts through and exposes nine feet of gravel one-fourth of an inch to one and a half inches in diameter, with much sand, and one to three feet of silt above. The

shore gravel here extends for about three-fourths of a mile, with a width of from three to five rods. The river bottom is here about 15 rods wide.

J. W. Colvin.—Northwest quarter of section 35 (5 S., 5 E.), Taylor Township. A gravel talus slope about 100 yards long extends about 40 feet above the road. This gravel is a mixture of chert fragments and small sandstone concretions derived from the disintegration of certain limestones and shales above. This forms a coating five to ten feet thick on the slope. The material packs well where it has been tried in the repair of roads.

Waite.—Section 2; Bert McRae, sections 3 and 10, and Kelly, sections 9 and 10 (6 S., 5 E.). Near the mouth of Four-Mile Creek, extending some three miles down the river, a gravel bar is exposed on these farms at very low water.

A gas well drilled several years ago on the farm of A. McCauley, west side of the east half of section 3 (6 S., 5 E.), Taylor Township, disclosed the following section:

Section of McCauley well.

		Feet.	Inches.
1.	Silt	40	..
2.	Gravel	10	..
3.	Clay	10	..
4.	"Soapstone"	140+	..
5.	Black shale—gas at bottom	97	..
6.	Limestone	..	6

J. O. Fox.—Fraction section 9 (6 S., 5 E.), Taylor Township. Here is another rather extensive gravel slope, about 75 yards long, 20 yards wide and 2 to 6 feet deep. The gravel is one to four inches in diameter, with considerable dirt intermixed.

Morvins Landing.—Northwest quarter of section 11 (6 S., 3 E.), Heth Township. A large gravel bar extends along the river about a mile in each direction, and 25 yards wide, more or less, according to the height of the river.

Greene Brandenburg.—Section 32 (5 S., 3 E.), Heth Township. From Mauckport down the river about a mile is a gravel bar, exposed at low water. Gravel was taken from this bar for the south end of the Corydon-Mauckport pike.

Lopps Landing.—Section 25 (5 S., 2 E.), Heth Township.

From about a quarter of a mile above to two miles below, gravel may be obtained when the river is low. Beyond this bar there is no gravel worth mentioning to the mouth of Blue River.

The New Amsterdam-Central pike was built in 1901. Crushed limestone was used on top of stone broken to about six inches in diameter. This pike is in very good condition.

The Corydon-Mauckport pike is made almost wholly of limestone. A bed of large pieces of broken rock was first laid. Then this was covered with a layer of rock crushed to a size to go through a two-inch ring. This part of the pike is smooth and solid. The part that was built of gravel has much coarse material on top and is liable to cut through with traffic in the spring.

The Corydon-New Albany pike in Harrison County is built of gravel. At first a plank road was laid. This in time gave place to the gravel. Creek gravel, consisting largely of limestone and chert, with some iron oxide, was the metal used. The pike has been repaired each year wherever it most needed it. The surface has, therefore, been continually building up and growing more solid. The top is smooth, with little loose material upon it.

Laconia Hill pike is a road leading from the Corydon-New Albany pike about a mile above Breckenridge toward New Middleton, which is being built by farmers. It is made of gravel such as comes from Little Indian Creek and other creeks in the neighborhood. It is a good, solid road, in marked contrast with the ordinary dirt road that formerly existed here. This is an example of what might be done in any township if attention were given to properly applying the usual labor of "working out taxes." The credit of the improvement of this road is due to Mr. Richart.

The Paoli pike in this county runs over a generally level country, with no outcrop of rock in the immediate vicinity. As in Floyd County, the pike is here very smooth and solid.

James W. McKinster.—Northwest quarter of section 36 (3 S., 3 E.), Harrison Township. Limestone outcrops on a hillside where a new pike is being built. About 500,000 cubic yards are available, with one to ten feet of stripping. The rock is a fine-grained, lithographic limestone, very hard. The sample from this place is from the Mitchell formation and is characteristic of much of that limestone over most of the county.

*Results of Physical Tests of Mitchell Limestone from land of J. W. McKinster.**

Specific gravity	2.5	French coefficient of wear.	8.8
Weight per cu. ft. (lbs.)	156	Hardness	13.6
Water absorbed per cu. ft. (lbs.)	1.97	Toughness	11
Per cent. of wear	4.5	Cementing value—Dry	24
		Wet	131

"A hard, tough rock, which develops an excellent cementing value. A good, all-around road material."—Page.

A chemical analysis of the sample made at the same laboratory resulted as follows:

Chemical Analysis of Mitchell Limestone from land of J. W. McKinster.

	Per cent.
Alumina (Al_2O_3)	.41
Iron oxide (Fe_2O_3)	.24
Lime (CaO)	51.80
Magnesia (MgO	3.00
Insoluble in hydrochloric acid	2.65
Loss on ignition	42.46
Total	100.56

* * *

In the construction of country rock roads in this area the best results are probably not attained through the common methods employed. While in some cases the contract calls for rolling the rock after it is applied, the usual custom is to spread the crushed rock and leave to ordinary traffic the work of packing and of putting on the permanent features of surface. The most frequent appearance of a newly made pike is to have two depressions, or ruts, which are formed by the wheels of heavy wagons running along the middle of the pike, where its highest part should be. Heavy traffic before the whole mass of rock has become packed solidly together ruins the smoothness and evenness of the surface, and permanent injury is done to the dirt grade underneath. An ideal cross section of a new rock pike left to the mercy of continuous and excessive teaming would appear somewhat as indicated in the following diagram:

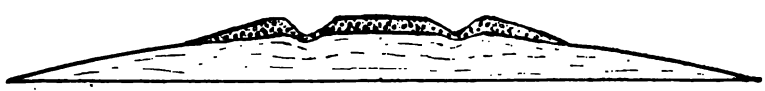
The depressions, cut into the clay below, catch and hold water, which has no way of escape except by evaporation or slow percolation through the almost impervious clay. These depressions must be refilled by surface applications of rock, after the road has be-

*For standard of comparison see p. 79.

come settled. With a liberal use of fine screenings, such conditions may be partially prevented, as the whole surface then settles more evenly. The use of a heavy steam roller, such as is employed on the streets of cities, would leave the newly built pike solidly packed throughout and with an even, smooth surface, over all of which traffic could proceed with equal facility. One such roller in each county would be sufficient to accommodate all advancements in road building throughout the county.

Gravel roads are very frequently ruined by heavy traffic during a prolonged wet spell of weather, or while the frost is coming out

Diagrammatic cross section of road that has been rolled during its construction, leaving a broad, even surface for traffic



Diagrammatic cross section of road that has been built without being rolled, showing effect of traffic upon road bed.

Fig. 50. Illustrating the effects of heavy traffic on a new unrolled pike road.

of the ground. Notwithstanding the ordinances to the contrary, every means is taken to evade them by hauling heavy loads at night, by misrepresenting to the officers who are charged with the enforcement of the law the actual weight of loads hauled, and by the weakness of these officers in not acting when they know of cases of infringement. The writer observed six teams, each hauling a load of logs of such great weight that it was only by the utmost exertion they could be drawn without a stop a distance of 20 rods over a level shale pike. After these teams had passed the road presented a spectacle which would rouse the wrath of any man who really cared for public interests.

The use of gravel that is too sandy and the application of soft, sandy and non-cementing limestone upon pikes should not be tolerated. The accumulation of loose material upon the surface of a road increases the difficulty in drawing a load over it probably 50 or more per cent.

It is rarely that enough cementing material is found in the river gravel or in the bank gravel to produce a surface as hard and smooth as that of a crushed limestone surface. Where pit gravel is taken out there is usually a layer of a foot or so just above the gravel, containing much iron oxide. This layer, when used with the other gravel for the top of the road, generally makes a more compact surface than when the clear gravel alone is used. It is usually too limited in amount to furnish any available supply. There is a possibility of some combination being made with the bank gravel, or the river gravel, and the red creek gravel of the Knobstone shale area which would result in producing a metal at once capable of forming a compact surface and having good resistance to heavy traffic.

While many regions are naturally unsupplied with limestone, and other material has been used for pikes, it should not be thought for a moment that these other materials are as serviceable and as permanent as the limestone. The best pikes in this whole area are made of limestone. It may be questioned whether many of those townships now using the local material—not limestone—would not be making a paying investment by shipping in limestone and using it on the roads as fast as improvements are made. The first cost would be greater, but in taking into consideration the accruing results of permanency, solidity and increased ease of travel, the advantage seems to be with the limestone pike.

A common practice in repairing roads is to put off the matter until the fall of the year. Such method leaves the road in bad condition for the winter. A better time, as suggested by one practical farmer, would be "just after corn-planting time." There is then a period of comparative leisure for all the farmers, and roads repaired at that time would be, by the beginning of winter, in as good condition as it were possible for them to be.

The making of the best roads and their maintenance are matters of enough importance to the farmer to merit his deepest interest. The best plan for road-making now being pursued in these counties is that of giving the work into the hands of experienced road-makers. The work of keeping the roads in good repair should be attended with equal care and skill. Experience has shown that it is not always safe to leave the construction in the hands of con-

tractors without direct supervision by road superintendents who can not be bribed. The election of unreliable men to township or county offices is probably responsible for much of the poorly constructed road. Not until the rank and file of the farmers insist on supporting a man for office, not because of party affiliations but from the principle of "the best man for the office," will they find their own interests conserved in the making of improved roads.

SECTION XII.

THE ROADS AND ROAD MATERIALS OF A PORTION OF CENTRAL SOUTHERN INDIANA.

EMBRACING THE COUNTIES OF BROWN, OWEN, GREENE, MARTIN, LAWRENCE, ORANGE AND WASHINGTON.

BY W. S. BLATCHLEY.

The counties above mentioned, together with Monroe and Jackson, comprise an irregular quadrangle area, approximately 50 by 65 miles in size, occupying the central portion of the southern half of the State. When it was seen that the assistants in the field, gathering data for this report, would not have time to finish the entire State before the season closed, the writer undertook the work in the counties comprising this area. On account of the many office and other routine duties which fall upon the director of the Department, I was able to give but a few days to each of the counties. As a consequence, the subject is not treated so much in detail as in the other counties where the assistant had more time at his disposal. It was at first the intention to cover both Monroe and Jackson counties along with the others, but finding that Mr. Charles W. Shannon, of Bloomington, had already made a special study of the road question in Monroe County, arrangements were made with him to furnish the report on that county, while Jackson County was afterward added to the territory assigned to Mr. R. W. Ellis.

General Geology of the Area.—The surface rocks of the seven counties treated in this section belong, for the most part, to the Sub-Carboniferous or Mississippian Period. The Knobstone formation covers the whole of Brown and the eastern portions of Lawrence and Washington counties. This formation comprises shales or shaly sandstones and its general characters have been set forth on preceding pages.* The only road material which it offers

*See Section V, p. 128.

is the creek gravel derived from the weathering of the nodules or concretions of siderite or iron carbonate which are abundant in the lower shale strata.

The Harrodsburg, Bedford Oölitic and Mitchell limestones lie, in order named, to the west of the Knobstone, and form the surface rocks of the greater part of eastern Owen, western Lawrence, northeastern Orange and western Washington counties. The Harrodsburg and Mitchell stones are both well adapted for macadam roads, but the intervening Bedford oölitic is too soft and should not be used for that purpose, if either of the others can be readily obtained.

The limestones and sandstones forming the Huron group come to the surface over a part of western Owen, eastern Greene, western Lawrence and eastern Martin counties, and also over the greater portion of Orange County. The middle and lower Huron limestones are, as already noted,* well adapted for road construction.

The rocks of the Coal Measures or Carboniferous Period form the greater part of the surface of the western halves of Owen, Greene and Martin counties, but have little to offer in the way of road material. Where the Mansfield sandstone is truly conglomerate in character, i. e., made up of quartz pebbles cemented together by iron oxide, as in portions of Martin County, it has been used to some extent as a surfacing material, but in the greater part of the area covered by the Carboniferous rocks the material for road-making will have to be imported.

Topography.—The area under consideration lies, for the most part, in the driftless region of the State, and is therefore a part of a great plain of degradation, formed by the removal of the original rock surface to an unknown depth and now represented by the summits of the flat and even-topped divides, ridges and hills. Subjected for millions of years to weather and stream erosion, its surface has been dissected into a complex network of valleys, interstream ridges and isolated knobs. With no mantle of drift to fill up the old preglacial valleys and cover the many outcrops of stone, it is at once the most rugged and the most picturesque portion of the State. That part of the area covered by the Mitchell lime-

*See p. 145.

stone is the most level, and, aside from the valleys of the larger streams, the most fertile portion of the region. This widens out to the southward and forms a broad, rolling area between the higher hilly region of the Huron and Mansfield groups on the west and the generally lower hills and valleys of the Bedford oölitic limestones on the east.

In the vicinity of Quincy, Owen County; Mitchell, Lawrence County; Orleans, Orange County, and Campbellsburg and Martinsburg, Washington County, the Mitchell area is a fine farming region, well adapted to the raising of cereals, blue grass or fruit. Aside from the valleys with their alluvial soil, the remainder of the area is poorly adapted to agriculture, the rocks coming close to the surface and the soil being mostly a residual clay derived from their decay.

Drainage.—Both the east and the west forks of White River flow through the area and, with their larger tributaries, comprise a most excellent system of drainage. This, for the most part, is to the southwest toward the Wabash. From southern Washington County, Blue River drains south to the Ohio, and from southern Orange the Patoka flows west to the Wabash. All these streams carry large quantities of gravel, which in many places has been used as a road material, though, for the most part, it is much inferior to the limestones in which the region abounds.

BROWN COUNTY.

Area in square miles	317
Population in 1900	9,727
Miles of public roads	350
Miles of improved roads	30
Percentage of roads improved	8.6
Miles improved with gravel	30
Miles improved with stone	0
Average original cost of gravel roads per mile	$1,028
Total cost of improved roads	$30,840
Annual cost of repairs per mile on gravel roads 5 years old	$15
First improved roads built	1899
Proportion of improved roads built since 1895 (per cent.)	100
Satisfaction of farmers with investment in improved roads	Good
Authority	Jno. B. Seitz, County Auditor

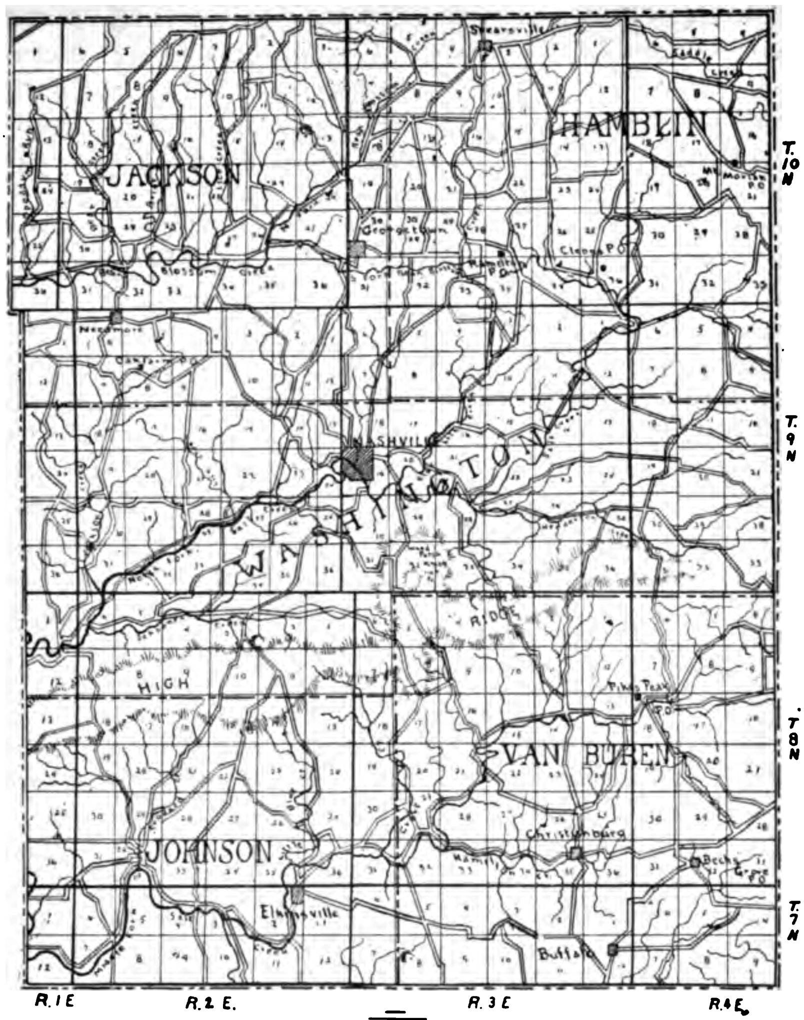
The northern boundary of Brown County is about 30 miles nearly due south of Indianapolis. The county is bounded on the

east by Bartholomew, on the south by Jackson and Monroe, on the west by Monroe, and on the north by Morgan and Johnson counties. It is quadrangular in shape, 20 miles long from north to south, by 16 miles in width from east to west. With the exception of fragments of the reddish crinoidal Harrodsburg limestone on a few of the higher ridges, the surface rocks of the county are wholly of the soft sandstones and shales of the Knobstone Epoch of the Mississippian Period. For that reason they have been easily eroded and the county is very broken, except in the southeastern corner, where there is a large area of level tableland. The "Knobs" of southern Indiana, stretching northward from Floyd County, attain, in "Weed Patch Hill," south of Nashville, the county seat, their highest elevation—1,147 feet above sea level.

Salt Creek, the principal stream of Brown County, is composed of three main branches—the "North," the "Middle" and the "South" forks, which unite near the southwest corner of the county and flow thence through Monroe and Lawrence into East White River. Thus almost the whole watershed of the county, together with a considerable portion of Jackson, on the south, is drained by this stream. Bean Blossom Creek has its source in the northeastern part, its principal tributaries in northwestern Brown being Bear and Lick creeks, both flowing nearly south.

High ridges surround the county on all sides, while from east to west and southwest three similar ridges traverse the county, all connecting on the divide near Trafalgar, in Johnson County. The first and the most northern constitutes the southern bluff of Indian Creek, and is called "Indian Creek Ridge"; the second, south of Bean Blossom Creek, is known as "Bean Blossom Ridge," and the third, passing nearly through the middle of the county, is named "Central Ridge." All these ridges slope gently to the south and west, but present steep faces to the north and east. The valleys of the county, now containing its richest soils, have been eroded by flowing streams, leaving the strata of the hills as they were originally deposited by sedimentation in an ocean which covered this region ages before the dawn of the Glacial Period.

As one ascends the higher elevations on some of the winding roads, knob after knob and ridge after ridge are unfolded to view, disclosing the knobstone topography in all its pristine beauty. The narrow valleys trend mainly east and west, making the slopes



ROAD MAP

OF

BROWN COUNTY

County lines

Township lines

Fig. 51.

of the ridges north and south. The latter are everywhere eroded into many gulches and ravines. Here and there, on some distant ridge, can be seen a roadway, winding in and out in great half-spiral convolutions, like a great snake, stretched out in lazy graceful curves. The greater part of the original growth of timber has been removed and the knobs and slopes of the ridges are now thickly covered with second growth and underbrush. It is one of the most rugged and picturesque portions of the State, well worthy the name of the "Switzerland of Indiana."

Only the northern third of Brown County is within the glaciated or drift area. The northwestern part of Hamblin Township and the greater portion of Jackson Township are covered with drift accumulations as far south as Bean Blossom Ridge, the drift being found on the slope of this ridge nearly 200 feet above the water in the stream. Boulders of granite, gneiss and jasper, three to five feet in diameter, occur frequently in this region. In the Salt Creek valley, northeast of Nashville, but little drift was seen. Bean Blossom Ridge, then, marks the southern limit of the first and only glacial invasion of the county.

Road Materials.

Aside from the drift gravel found along Bean Blossom and its tributaries in Jackson and Hamblin townships, the only material suitable for the improvement of roads in Brown County is the so-called "creek gravel," derived from the weathering of the iron nodules in the lower portion of the Knobstone shales. This gravel occurs in quantity in the bars along every small stream in the county, and results have proven that it is fully as good, if not better, for road-making than much of the drift gravel which has been so commonly used in the counties to the northward. It is usually in small, rectangular pieces, with sharp edges, the latter not having had time to be worn off since the concretion of siderite was broken up by weathering.

The roads constructed from creek gravel are light reddish brown in color. The gravel is compacted by traffic in a few weeks into a hard, smooth, even-surfaced roadway, which seems to be as durable as the average improved road of the State. They are less noisy than the ordinary gravel roads, as the iron carbonate is free from that quartz or "grit" which causes a grinding noise when it meets the tire of a heavily loaded wagon. Since the first roads

Plate XII.

Slope of weathered Knobstone shale, showing the formation of creek gravel from nodules of iron carbonate. Side of Columbus-Nashville pike, four miles west of Columbus.

Bar of creek gravel on Henderson Creek, near Mt. Liberty, Brown County.

were constructed from this gravel in 1899, there has not been time sufficient to fully prove its durability. It is said that in March and April the surface of the roads becomes somewhat sloppy, but they are seldom, if ever, cut into deep, miry places. They are not washed into gullies by heavy rains as readily as roads built of either drift or river gravel, as the material packs more firmly together, the iron carbonate acting in this respect much like a cement.

An average sample of the Knob creek gravel, collected on Wolf Creek, Bartholomew County, by Dr. M. N. Elrod and Mr. F. M. Stevens, of Columbus, was tested at the Road Laboratory at Washington. The results show its dry grinding cementing value to be 74, as against the average of 82 for 59 samples of gravel previously tested at the same laboratory, while the wet grinding cementing value was 190. Of it Mr. Page wrote: "Cementing value excellent. Admirably suited for a binding material for road surfaces."

Along Henderson Creek, in the eastern part of the county, large beds of this gravel were noted, esepcially near Mt. Liberty. Numerous bars were also seen along the tributaries of the Middle fork of Salt Creek in northern Van Buren Township, and along the tributaries of Bean Blossom Creek in Jackson and Hamblin townships. In the latter, or northern third of the county, probably one-third of the material in the bars is of drift origin, and care should be taken to remove the pieces over two inches in diameter. In other localities the gravel, as far as noted, will not need screening.

Only the eastern and northern portions of the county were visited, but careful inquiries show that the creek gravel occurs everywhere along the streams, and in sufficient abundance to easily and cheaply improve every public road in the county.

Improved Roads.

While but 30 miles of improved road have so far been constructed under contract, many of the public roads have been partially covered with creek gravel. If they had been properly graded and drained, this improvement would have been permanent, but as it is the great majority of them will cost as much or more to improve as a new road or one on which no gravel has been placed.

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The main road or highway, 20 miles in length, between Columbus and Nashville, was improved in 1901. Seven miles of the eastern end were surfaced with river gravel, and the remaining 13 miles with the Knobstone gravel. This road was in good condition in September, 1905, that portion made of Knob or creek gravel being, if anything, the better and the more agreeable to travel.

In Van Buren Township the main road running east and west through Pike's Peak was improved by assessment on the farmers and was later turned over to the county to be kept in repair. The same plan has been followed on several of the principal roads of Johnson Township.

In summer and autumn the surface of the unimproved country roads of Brown County is in fair condition. The grades, however, are many of them entirely too steep, especially those of the north and south roads, which ascend and descend the main ridges. Where improved roads are built, many cuts and fills will have to be made to reduce these grades to anything approximating 4 per cent. It will be found far better and cheaper to relocate the roads in many places, rather than to improve those now existing. Aside from the grading, the roads of the county can be permanently improved very cheaply, as the creek gravel is so generally distributed that it will not have to be hauled over three or, at the most, four miles at any one locality.

OWEN COUNTY.

Area in square miles	393
Population in 1900	15,149
Miles of public roads	692
Miles of improved roads	200
Percentage of roads improved	28.9
Miles improved with gravel	30
Miles improved with crushed stone	170
Average original cost of gravel roads per mile	$1,900
Average original cost of stone roads per mile	$1,800
Total original cost of improved roads	$363,000
Annual cost of repairs per mile on stone roads 5 years old	$50
Miles of gravel road built in 1905	4
Miles of stone road built in 1905	5
First improved roads built	1885
Proportion of improved roads built since 1895 (per cent.)	80
Authority	Geo. O. Mitten, County Auditor

Owen County lies southwest of the center of the State and is bounded on the north by Putnam, on the west by Clay, on the south by Greene and on the east by Morgan and Monroe counties.

The geological epochs represented in the county are seven in number, viz., the Knobstone, the Harrodsburg, Bedford Oölitic, Mitchell and Huron limestones of the Lower Carboniferous, and the Mansfield Sandstone and Coal Measures of the Carboniferous Period.

The Lower Carboniferous rocks form the outcropping strata over much of the eastern part of the county and are most readily recognized by the presence of heavily bedded limestone. This limestone at places immediately underlies the Coal Measures; at other places there is a considerable thickness of shale or sandstone between. The Knobstone and Harrodsburg limestones occur only along the eastern border of the county; the former outcropping along the bluffs of White River near Gosport; the latter being found over an area of several square miles above and below that town, and also over a small area in the northeastern corner of the county. The Bedford oölitic limestone forms the surface of several parts of sections just to the west of the Harrodsburg and has been quarried extensively at Romona and near Spencer. The Mitchell is the predominating limestone over the eastern half of the county, and has been used in a number of places for macadam purposes. The Huron limestones and sandstones are exposed mainly along the streams of the western half, where the overlying Mansfield sandstone has been eroded from above.

The Mansfield sandstone forms the surface of irregular patches or tracts of the higher land in the western half. These table-lands often cover an area of a dozen or more square miles and are characterized by possessing a less fertile soil than that above the limestones. The Coal Measure rocks proper lap over the western edge of the southern part of the county, covering an area of 15 to 18 square miles north and south of Coal City, and also a very irregular tract of 8 or 10 square miles in the vicinity of Patricksburg.

In the northeastern part of the county, near Quincy, the surface is rolling, the valley of Eel River broad, level and shallow. From the northwestern to the southeastern corner stretches a belt of high hills or ridges and deep, narrow valleys, the ridges rising 150 to 250 feet above the valleys and up to 300 feet above White

River. To the southwest the hills become lower and broader, with broader valleys between. All but the southeastern corner of the county lies in the drift area. Over its hillier part the drift is shallow or wanting, so that it interferes but little with observing the rocks. Toward the northern and southwestern parts the drift increases in depth, but still probably averaging less than 20 feet and not often running over 30 feet in thickness.

The principal stream is the West Fork of White River, which flows across the southeastern corner of the county from northeast to southwest. Its tributaries are Mill, Rattlesnake and Fish creeks from the north, and McCormick's and Raccoon creeks from the south and east. The South Fork of Eel River, rising near the northeastern corner of the county, flows west or northwest and joins the main or North Fork in the southwestern corner of Putnam County. It then swings around through eastern Clay County and, after receiving the Jordan, Six Mile and Lick creeks, crosses the extreme southwestern corner of Owen County, flowing a little south of east. All these streams furnish ample drainage and have, by their erosion, rendered the greater part of the surface of the county very rough and broken.

Road Materials.

Harrodsburg Limestone.—The eastern two-thirds of Owen County is bountifully supplied with road material. The Harrodsburg limestone outcrops in a number of places in sections 19, 20, 21 and 24 (12 N., 2 W.), Harrison Township, in the northeastern corner of the county; also in sections 4, 5 and 6 (11 N., 2 W.) of the same township. The same stone also occurs abundantly in the hills north, west and south of Gosport, and has been used in the construction of a number of miles of road in the vicinity of that town. It also occurs in the hills and bluffs on the south side of White River, in the northeastern portion of Washington Township. It is a heavy bedded, dark gray, hard, rough limestone, with intercalated beds of clay containing in places many geodes and partings of chert. At Cave Spring, in the northwest quarter of section 5 (11 N., 2 W.), the following section is exposed:

Section at Cave Spring.

		Feet.
1.	Harrodsburg limestone crowded with crinoid stems	20
2.	Clayey limestone with suture partings at fossil beds	22
3.	Hard, blue limestone in beds of 1 to 2 feet, with fossils; outlet of spring	7
4.	Clayey sandstone, geodes and thin plates of limestone	11
5.	Knob standstone, etc	25
	Total	85

On the slope of the hill at Gosport there is an exposure of 24 feet 6 inches of Harrodsburg limestone in two beds, the upper 20 feet; the lower, 4 feet 6 inches thick. Between the two is a clay shale 1 to 4 feet in thickness. These strata dip to the southwest 30 feet to the mile.

While not as good a road material as the Mitchell limestone, the Harrodsburg will make a good and durable road and there is no excuse for unimproved roadways where it can be had in quantity close to the surface both under and alongside the country roads of this region of the county.

Bedford Oölitic Limestone.—This well-known building stone comes to the surface over limited areas in Harrison, Wayne and Washington townships. It is quarried for building purposes on an extensive scale at Romona, a station on the I. & V. Railway between Gosport and Spencer. While it will make a fair macadam road it is, on account of its softness, inferior to both the Harrodsburg and Mitchell limestones as a road material and will not, therefore, be mentioned further in this connection.

Mitchell Limestone.—This limestone forms the surface rock and is exposed at numerous points along the ravines and streams of a large area in eastern Owen County. It covers nearly the whole of Harrison and the eastern half of Jennings; also the greater portion of Montgomery and Washington townships. It forms the surface rocks along the northern and eastern tiers of sections of Clay Township, with outcrops at numerous localities on Raccoon Creek and also along White River in Franklin Township as far down as section 16. It is typically a thin layered, heavy bedded limestone, often concretionary or argillaceous, sometimes dark colored from disseminated iron. The upper division is often in thin layers, and has been quarried for paving stones at the old Fletcher quarry near the mouth of Rattlesnake Creek

and at Mills' quarry on Mill Creek. At Stone Cut, on the C., I. & L. (Monon) Railway, a mile north of Cave Spring Station, the lower division of the Mitchell, rich in its characteristic fossils, is well exposed.

Numerous small quarries have been opened in the Mitchell limestone of Owen County for securing macadam or crushed stone for local use for road making purposes. Several of these are located along the Spencer and Cataract road in Washington and Montgomery townships, and furnished material for its building. One on the north side of the I. & V. Railway, 3/4 of a mile below Romona, was worked on an extensive scale for several years, but has now been abandoned. The top layers of the Mitchell were there crushed for macadam purposes and shipped mainly to Greene and Sullivan counties, while the lower courses were used as a flux by the Illinois Steel Company, of South Chicago.

Other quarries which were visited were on the "Texas" road, 1½ miles northwest of Spencer; on the Patricksburg road, in the northwest quarter of section 23 (10 N., 4 W.), and on the Rattlesnake road, in the northwest quarter of section 13 and the southwest quarter of section 2 (10 N., 4 W.). The quarry on the "Texas" road had just been opened and was being operated to furnish stone for a road then building. The exposure was 12 feet in thickness, with 3 to 5 feet of stripping above. The two upper layers, aggregating 24 to 28 inches, were semi-oölitic and subcrystalline in structure, while the lower ledges, 4 to 12 inches thick, were of the fine grained, close textured structure which characterizes the best of the Mitchell stone. An average sample taken from the loaded wagons was sent to the laboratory of the Office of Public Roads at Washington for testing, the results showing as follows:

*Results of Physical Tests of Mitchell Limestone from quarry one and a half miles northwest of Spencer.**

Specific gravity	2.6	French coefficient of wear	11.8
Weight per cu. ft. (lbs.)	162.2	Hardness	4.5
Water absorbed per cu. ft. (lbs.)	3	Toughness	9
Per cent. of wear	3.4	Cementing value—Dry	20
		Wet	45

"About the average in hardness and toughness for limestone, and above the average in resistance to wear; cementing value good. Should give good results under highway and country-road traffic."

*For standard of comparison see p. 79.

Plate XIII.

Quarry of Mitchell limestone by the side of the "Texas" road, one and a half miles northwest of Spencer, Owen County.

Rock crusher used in preparing macadam material from above quarry for "Texas" road.

The chemical analysis of the same stone showed its constituents to be as follows:

Analysis of Mitchell Limestone from quarry one and a half miles northwest of Spencer.

	Per cent.
Alumina and iron oxide ($Al_2O_3+Fe_2O_3$)	1.50
Lime (CaO)	29.70
Magnesia (MgO)	7.00
Phosphoric acid	.10
Insoluble in hydrochloric acid	30.43
Loss on ignition	31.38
Total	99.91

At the quarry on the Patricksburg road, 3 miles west and 1 mile north of Spencer, a crusher owned by the township is still in place. The Mitchell stone, here capped with 2 to 4 feet of Huron sandstone and 3 to 5 feet of clay, has been opened to a depth of 14 feet. The stone for several miles of the Patricksburg road was secured at this quarry.

The quarries on the Rattlesnake road have been opened to a depth of 15 to 18 feet in the Mitchell, the upper layers of which show semi-oölitic in structure, with the middle layers in part cherty and the lower portion the close-textured blue-gray stone.

Along McCormick's Creek, east of Spencer and south of White River, the Mitchell stone is exposed in great abundance. One outcrop on the farm of Rufus Cline was being worked to furnish macadam for 2½ miles of road southeast, in what is known as the Flat-woods district. From 2 to 4 feet of stripping was being removed and 12 feet of the exposed stone then quarried and crushed. The contractor paid the owner 2 cents per cubic yard for the stone. A fine exposure of the Mitchell stone, which could be used to advantage on the road, occurs at the south end of the new wagon bridge across White River, 1½ miles southwest of Gosport.

The largest and most extensively worked quarry of Mitchell stone in Owen County is that of the Spencer Stone Company, located on a spur of the I. & V. Railway, ¾ of a mile southwest of Spencer, in the northwest quarter of section 29 (10 N., 3 W.). This quarry has been opened for 35 years, and for a long time was operated by Bernhard Schweitzer, who quarried and shipped

large quantities of rubble stone and also burned lime from certain of the strata. Since 1900 it has been operated mainly for furnishing macadam stone on a large scale for the roads of Owen and adjoining counties. The company owns 20 acres of land, on one side of which the crushing plant and quarry are located. After removing 4 to 6 feet of clay the quarry has been opened to a depth of 51 feet in the Mitchell stone. A 4 to 6 foot ledge on the top is a bastard oölitic stone, below which are several thin layers, aggregating 8 feet in thickness, which contain numerous chert nodules. The remainder is a close grained, blue-gray limestone in layers 2 to 14 inches in thickness. These after blasting are easily broken by sledges and loaded into tram cars, which are hauled to the crusher. The floor of the quarry is level with very little refuse. From the lower ledges, rubble and building stone are secured in sufficient quantity to satisfy the demand. Both upper and lower surfaces of this rubble stone are very smooth and require no working.

An average sample from a mixture of the different layers was tested at the U. S. Road Testing Laboratory with the following results:

*Results of Physical Tests of Mitchell Limestone from quarry of Spencer Stone Company, Spencer.**

Specific gravity	2.68	French coefficient of wear	10.87
Weight per cu. ft. (lbs.)	168.4	Hardness	6.3
Water absorbed per cu. ft. (lbs.)	.88	Toughness	10
Per cent. of wear	3.68	Cementing value—Dry	8
		Wet	21

"Rather high resistance to wear for limestone, but rather low cementing value. Should give satisfactory results under highway traffic."

A chemical analysis of the stone made at the same laboratory showed its composition to be as follows:

Analysis of Mitchell Limestone from quarry of Spencer Stone Company, Spencer.

	Per cent.
Alumina and iron oxide ($Al_2O_3+Fe_2O_3$)	.85
Lime (CaO)	50.25
Magnesia (MgO)	Trace
Insoluble in hydrochloric acid	9.49
Loss on ignition	39.61
Total	100.20

"The insoluble portion is fine silt."

*For standard of comparison see p. 79.

The crushed stone from this quarry has been used for the making of macadam roads in Owen, Sullivan, Knox, Daviess, Greene, and Morgan counties. Where the roads have been properly built it has everywhere given the best of satisfaction.*

Huron Limestones.—The rocks of the Huron Group come to the surface over a large portion of western Owen County, especially in Morgan, Lafayette and Franklin townships. The Huron sandstones cap many of the hills between Spencer and Santa Fe and those southwest of Spencer toward Freedom. The Huron limestones are not as well represented in this county as further southward. In a number of places, however, they will be found of sufficient thickness and close enough to the surface to be utilized as road metal, a use for which they are, in general, well adapted. At Jackson's Bluff, southwest quarter section 33 (9 N., 4 W.), between Freedom and Farmers, the upper Huron limestone is exposed 18 feet in thickness. On the slope of the hill southwest of Freedom, east half of section 20 (9 N., 4 W.), the same ledge of stone is 22 feet thick. Other exposures of the same stone 11 to 18 feet in thickness, occur between Arney and Patricksburg, in sections 26, 34 and 36 (10 N., 5 W.); in the northeast quarter of 22, just southeast of Patricksburg; along Fish Creek, in the southwest quarter of 33 (10 N., 4 W.), and in sections 5, 6 and 7 (10 N., 4 W.), northwest of Vandalia, in Lafayette Township. Still others occur in Morgan Township, notably in sections 28 and 31, south and southwest of Atkinsonville. Any or all of these will furnish a fair grade of road metal.

Overlying the Huron limestone is the Mansfield sandstone, which has been used to some extent for road metal, but is wholly unfit for that purpose.

Gravel.—Extensive bars of gravel occur along White River, in numerous places, and along the other principal streams of the county. This gravel is largely composed of limestone and sandstone pebbles from the country rocks and is, therefore, much inferior to the drift gravel of the counties to the northward. It has, however, been used to some extent for surfacing the roads.

In but few places do deposits of drift gravel occur of sufficient size to justify working. One of these is near the schoolhouse on

*See subsequent page for description of crusher, etc.

the Patricksburg road, in the southeast quarter of section 14 (10 N., 4 W.). A pit has here been opened to a depth of 12 to 18 feet. From 2 to 8 feet of clay surface must be stripped to secure the gravel. The latter is cemented quite firmly with calcium carbonate and when placed on the roads packs very closely. Some 3,000 yards have been sold at 5 cents per yard for repairing the unimproved roads of the vicinity.

Improved Roads.

Owen County, considering its size and resources, has spent a large sum of money on improved roads, especially in the last 10 years, but the auditor in his report to me has well said that "the farmers think the roads are not what they ought to be for the money spent." With an abundance of excellent macadam stone fairly well distributed, a careful and close supervision by experienced roadmasters should have resulted in far better roads for the money expended.

The only gravel roads in the county are in Jackson Township, in the northwest corner. They are built of Eel River gravel and cost $1,900 per mile.

Of the stone roads, those from Spencer to Patricksburg and from Spencer to Cataract are probably the best. Both were made of Mitchell stone, which is the best road material in the county; but on both of them are grades which handicap the hauling of full loads.

In the western part of the county several roads have been recently constructed of sandstone and creek gravel. One of these, 17 miles in length in Jefferson Township, extends from Middletown to Coal City. Another, 11 miles in length, is in Marion Township. Six inches of broken sandstone thrown loosely on the grade was used as the bottom layer. Over this was spread 4 inches of creek gravel. Being recently built, the defects of these roads are not yet visible, but time will show that a mistake has been made in the material, as sandstone is wholly unfit for use in any part of the road. As soon as the surface is worn through the sandstone will be ground into powder and large ruts and miry places will result. Moreover, as the sandstone lacks in cementing qualities, the larger pieces will, in time, work up through the gravel and make a very rough surface.

STONE CRUSHING PLANTS.

The largest and only permanent crushing plant in the county is that of the Spencer Stone Company, erected in 1900 at a cost of about $20,000. It is well constructed, but its location is not of the best, as it is on a hill at the top of a heavy grade, when it might have been built on the level of the railway and the stone lowered to it by gravity. The stone, after being blasted and broken into convenient size, is loaded into tram cars and hauled up an incline by steam and dumped into a No. 7½ Gates crusher. Passing through this it is elevated to a revolving screen 16 feet long by 40 inches in diameter, with perforations ½, ¾, 1¼, 1½, 2, 2½ and 3 inches in size. The 2-inch openings were being used at the time of my visit, as the contract (for roads in Sullivan County) called for straight 2-inch crusher run material, which includes everything from 2 inches down. However, not 1 piece in 30 was 2 inches in its largest diameter, the greater part running from ¾ to 1½ inches and from 18 to 25 per cent. being ½-inch screenings or less. All was being dumped promiscuously in the same car, this being the desire of the road contractor. The return stone, or in this instance that over 2 inches in size, is again passed through a No. 4 Gates crusher and reduced to the proper size. From the screens the broken stone is passed directly into large bins set above the railway switch. Cars are pushed beneath these bins and a sliding horizontal trap door is pulled to one side, allowing the stone to fall into the car, the loading of a car in this manner not taking over 8 to 12 minutes.

Drilling in the quarry is done by steam, a separate boiler being used. The cost of explosives averages about 3 cents per cubic yard of stone on account of the many thin layers of the rock.

The output of the plant runs from 300 to 500 cubic yards per day, according to the demand and supply of railway cars. The stone is all sold by weight, 2,500 pounds to the yard, though, according to the specific gravity, a cubic yard of solid stone weighs 4,546 pounds. The average railway car holds 31 cubic yards. The stone is sold at 50 to 62½ cents per cubic yard, f. o. b. the plant, the present freight rates to most points where it is shipped being 40 cents per ton. On an average, about 1,200 cubic yards are used to the mile. Thirty-five men are employed

in both quarry and plant. Day laborers receive $1.40 to $1.50 per day. Piece workmen, who break and load the stone into tram cars, receive 10 cents per car holding 1 1-5 yards, making at this price $1.50 to $2.25 per day. The plant is operated about 9 months each year, shutting down in December and resuming in March.

The stone shipped from this plant is all free from dirt, and if screened and placed on the roads in the proper manner, offers as good a road material as is found in the territory in which it is used. It is sold at a reasonable price and yet yields a fair profit to the operating company.

Besides the township crusher, which was idle at the quarry on the Patricksburg road, but 2 others were seen in the county. The one operating on the Texas road, northwest of Spencer, was a No. 3 Gates crusher with a capacity of 75 yards daily. The stone was being hauled in wheelbarrows and dumped directly into the machine, 12 men being employed at both quarry and crusher.

At the Cline quarry southeast of Spencer a Fort Wayne jaw-crusher was in use. It is operated at a lower level and will take in a larger sized stone than the Gates. Ten hands were employed in its operation and in supplying the stone from the quarry, the output being 65 to 75 tons per day.

GREENE COUNTY.

Area in square miles	482
Population in 1900	28,536
Miles of public roads	900
Miles of improved roads	350
Percentage of roads improved	38.8
Miles improved with gravel	25
Miles improved with crushed stone	25
Miles improved with stone and gravel	300
Average original cost of stone roads per mile	$2,500
Average original cost of gravel roads per mile	$1,500
Average original cost of combination (stone and gravel) roads per mile*	$1,600

*Part of the gravel used in the western section of the county is from the Merom deposits along the Wabash River, and is excellent. However, this gravel adds much extra expense to construction. The sentiment is growing in favor of all limestone roads, and the limestone ought to be fully a foot thick. The 50 miles of new road contracted for 1906 will cost $109,770. This amount is not included in the total cost above given.—W. B. M.

Total original cost of improved roads	$576,000
Annual cost of repairs per mile on all kinds of improved roads	$65
Miles of improved road built in 1905	20
Miles of improved road contracted for 1906	50
First improved roads built	1890
Proportion of improved roads built since 1895 (per cent.)	80

Satisfaction of farmers with investment in improved roads—

"Good, but not satisfied with the continuous flimsy process of repairs. The leading question now is 'Repair.' 1st, to get good material, and, 2d, to get competent men as superintendents of repair."

Authority .... W. B. Maddock

Lying near the center of the southwestern quarter of the State is the county of Greene, comprising a rectangle 30 miles long from east to west by 18 miles in width from north to south. It lies west of Monroe, south of Owen and Clay, east of Sullivan and north of Knox, Daviess and Martin counties.

The rocks of four different geological epochs form the surface of the county, viz., the Mitchell limestone and Huron group of the Lower Carboniferous and the Mansfield sandstone and Coal Measures of the Carboniferous periods. The Mitchell limestone comes to the surface only over small, irregular areas in the northeast and southeast corners of the county. The limestones and sandstones of the Huron group form the surface of the greater portion of the eastern half of the county, being exposed everywhere along the streams, which have worn their way down through the softer overlying Mansfield sandstone. East of White River the latter formation occurs in very irregular isolated areas which comprise the crests of the higher ridges and hills of this section of the county. West of White River the Mansfield sandstone forms the surface of two large disconnected areas which lie adjacent to that stream, and are separated by a narrow tongue of the Coal Measures, which extends east to the river opposite Bloomfield. The Coal Measures proper are practically limited to the western third of the county, only 3 or 4 small isolated areas being found east of White River.

The topography of the eastern portion of the county is very broken. The divides are usually very narrow, as are the stream channels, with steep slopes between. As White River is approached the topography becomes less broken. West of the river are extensive marsh-like prairies, evidently filled up valleys, while the divides between are broad rolls rising from 25 to 75 feet above

the level prairies. In the northwestern corner of the county the stream channels are narrow, with rather steep banks, rising to narrow divides.

The county is divided into almost equal halves by the west fork of White River, which flows in a southwesterly direction across its center. With the exception of the northwestern and southeastern corners, all of the drainage is into White River. The main branches from the east are Richland Creek, with its tributaries, Beech and Plummer's creeks and Doan's Creek, while from the west are Eel River, Latta's, Beech and Black creeks. Indian Creek, a tributary of the East Fork of White River, drains the southeastern corner, while the head waters of Busseron Creek extend up into the northwestern corner.

The eastern end of the county lies within the boundaries of the driftless area of the State. Over the uplands of the rest of the county the drift is generally met with, though usually less than a score of feet in depth. In the lowlands and prairies the deposits are found to be considerable, often over 100 feet in depth, these places evidently being old preglacial valleys which have been partially filled.

Road Material.

Greene County is but fairly well supplied with road-making materials. Lying as it does mostly to the west of the principal macadam limestones of the State, and south of the drift gravel region, it has to depend largely upon river gravel, on the little known Huron limestones, or on sandstone, which is always a very poor road metal.

Mitchell Limestone.—This well-known and valuable limestone for road purposes occurs over but a small area of the county, being exposed only along the head waters of Richland Creek from a point a mile southeast of Newark to the northeastern corner of Beech Creek Township and along Indian Creek east of Owensboro, in the southeastern corner of Jackson Township. In both these localities it will be found in sufficient abundance at a number of different points to furnish a first-class road metal for all unimproved roads within easy hauling distance.

Huron Limestone.—The rocks of the Huron group lie close to the surface over the greater part of Greene County east of White River. On the higher ridges and hills they are capped with the

Mansfield sandstone. For the most part the exposed Huron rocks are also sandstone, but at several localities there are outcrops of the hard bluish Huron limestone which appears well adapted for road improvement.

The principal one of these exposures visited was on the land of George Cox, southwest quarter of the northwest quarter of section 3 (7 N., 4 W.). At this point the Indianapolis Southern Railway Company was constructing a viaduct 2,215 feet in length and 147 feet in height across Richland Creek, and a quarry had been opened to secure crushed stone for the concrete work in connection therewith. At this quarry the blue limestone was exposed in 14 layers each 4 to 30 inches in thickness and aggregating 17 feet. This limestone was both overlain and underlain with a Huron sandstone, the overlying portion being 3 to 7 feet in thickness which, with a foot of soil, had to be stripped. The limestone appeared to be very hard and semi-crystalline in structure. About 45 yards of screened stone for the concrete work were being quarried and crushed daily on a portable Canton, Ohio, jaw crusher. For this the contractor was getting $1.00 per yard at the plant. Samples taken at the crusher were tested at the U. S. Road Testing Laboratory, the results of the tests showing as follows:

*Results of Tests of Huron Limestone from quarry near crossing of Indianapolis Southern Railway and Richland Creek.**

Specific gravity	2.7	French coefficient of wear	13.2
Weight per cu. ft. (lbs.)	168.4	Hardness	13
Water absorbed per cu. ft. (lbs.)	1.15	Toughness	10
Per cent. of wear	3	Cementing value—Dry	21
		Wet	66

"A very hard and fairly tough limestone, with good resistance to wear and cementing value. Suitable for suburban and highway traffic."—Page.

An analysis of the stone made at the same laboratory showed its constituents to be as follows:

Analysis of Huron Limestone from quarry near crossing of Indianapolis Southern Railway and Richland Creek.

	Per cent.
Alumina (Al_2O_3)	.25
Iron oxide (Fe_2O_3)	.75
Lime (CaO)	50.40
Insoluble in hydrochloric acid	7.17
Loss on ignition	40.92
Total	99.49

*For standard of comparison see p. 79.

Another exposure visited was on the land of George Shipman, northeast quarter section 15 (7 N., 4 W.), where a quarry has been worked for macadam road material. At this point the blue Huron limestone was exposed to a thickness of 15 to 17 feet, with 4 to 7 feet of buff Huron sandstone overlying. Sufficient material to cover six miles of road had been secured at the quarry, the supply in sight being practically inexhaustible.

The same stone outcrops at many points along Beech Creek, and especially in section 12 (7 N., 4 W.), where it forms part of a great precipice or perpendicular bluff, 120 feet or more in height, the upper portion of which is a massive bed of Mansfield sandstone. At the junction of the limestone and overlying sandstone there is at this point a large spring which was, at one time, used to run the overshot wheel of a gristmill.

Another exposure of the limestone which may be used for road metal is on the Ore Branch of Richland Creek, in the northwest quarter of section 28 (7 N., 4 W.), and a number of others can doubtless be found with little search.

This stone has been used in building 24 miles of macadam roads in Richland and Center townships. The oldest of these has been in use eleven years, with but few necessary repairs. On account of its hardness, the stone takes some time to pack and get smooth, but when it does so it makes a very hard and durable road.

Gravel.—Aside from the limestones above mentioned the only available road material in Greene County which should be used is the gravel found in extensive bars along White River and the larger creeks. That along White River has been extensively used for road purposes in the townships bordering that stream. The bars occur both in the bed of the river and on the lowlands close alongside, where they are formed during every freshet. That on these outside bars is finer than that in the bed of the river, and all of it contains too much sand to be used without screening, though the most of it has been so used in the past. It does not pack or cement as readily as does the drift or pit gravel farther north, and for that reason, whenever the season is dry, the sand works to the top of the road and makes very heavy hauling. The gravel bars are claimed by the owners of the adjoining land and the gravel is usually sold to the road contractors at 5 cents per cubic yard.

Plate XIV.

Quarry of Huron limestone on land of Geo. Cox, near the viaduct of the Indianapolis Southern Railway across Richland Creek.

Gravel bar on White River, one and a half miles northwest of Bloomfield.

Just above the wagon bridge across White River, 1 mile west of Bloomfield, the E. & I. Railway has a spur running out to extensive bars. Here a private firm has had for several years a steam pump on a large barge or house boat. With it the gravel has been sucked up from the bed of the river, screened and dumped directly into the car, the tracks being laid in the sha low water, so that the car could be run close to the pump. This gravel was shipped mainly to Daviess County, where it was used in road construction.

The gravel deposits along White River are extensive enough to build many miles of road. If properly graded and constructed, this road would be sufficiently durable under the traffic of the region, provided the gravel used was screened, and all that passed through a No. 4, or ⅜-inch mesh discarded. Used as it occurs, without screening, the cost of the roads would be too great for their durability, while the cost of the annual repairs made necessary would soon more than counterbalance the cost of screening.

Improved Roads.

While Greene County ranks well in number of miles of improved roads, the condition of many of these roads is not of the best. This is due to the fact that a number of them have been constructed in part of sandstone, this stone being broken into pieces 3 to 8 inches in size, dumped onto the grade, spread out roughly with a rake or other implement, and then covered with 3 or 4 inches of creek or river gravel and left for traffic to compact. In many places, especially where the grade or foundation is any way sandy, the sandstone does not bed down or compact. but gradually works its way to the top and the road becomes bumpy and disagreeable to travel. On hillsides and grades, where the rainfall washes the top dressing of gravel, this road is especially rough. Moreover, both sandstone and gravel readily grind up under heavy loads, and as the former is wholly lacking in cementing qualities, the ruts fill with dust which will not pack. Into these the larger pieces of sandstone work in time, and cause a rough, jolting roadway. It is best, therefore, never to use sandstone in the construction of any improved roadway unless it is covered with 4 to 6 inches of a material which will compact

quickly and finely, and so furnish a hard, smooth surface which will keep the underlying sandstone in place. Even then sandstone should not be used if limestone or good gravel is to any extent available.

In Beech Creek Township there is not a mile of improved roadway, though the Mitchell limestone, the best road material in the county, occurs in quantity. Specifications were, in 1905, prepared and advertised for 8 miles of improved roads in this township, of which the bottom layer of the surface material was to be limestone hauled in large pieces onto the road and there napped or broken so that all pieces would pass through a 4-inch ring. This was to be 5 inches thick, and on it was to be placed a second layer of limestone 3 inches thick, broken until no piece would pass through a 1-inch ring. The commissioners had the right to change this top dressing from the limestone to creek gravel if they so desired. The roadbed was to be 9 feet wide and the material gauged between 8-inch planks placed on edge. This road of 8 miles was estimated to cost $14,685, or $1,870 per mile. Even at that figure, with the rude method of construction specified and with limestone abundant no bidders could be had and the road was not built.

In Highland Township bonds have been recently sold for 6+ miles of improved roads to be constructed of river bar gravel at a cost of $2,500 per mile.

In Jefferson Township every road has been improved, some wholly with river gravel, others with a sandstone base and a top dressing of gravel and still others with Mitchell limestone from Spencer, Owen County.

In Smith Township 3 roads, aggregating 10 miles in length, have been constructed of gravel from the bars of Eel River, at a cost of $2,500 per mile.

In Wright and Stockton townships there are a number of miles of improved roads, the material used being either Mitchell stone from Spencer, or Wabash River terrace gravel from near Merom, Sullivan County. More than $31,000 will be expended for new improved roads in Stockton Township in 1906.

In Grant Township 7 miles of road were improved in 1905, the material used being Spencer limestone and gravel, the former comprising the 6-inch bottom layer and the latter the 3-inch top

layer. The roadbed is 9 feet wide and the limestone supposed to be less than $2\frac{1}{2}$ inches in diameter.

In Stafford Township a number of miles of road were also being improved in 1905, the surface material being gravel from Sullivan County. The total cost of the improvement will be $32,124.

About 1895 the 5 southwestern townships, viz., Fairplay, Grant, Stockton, Stafford and Washington constructed about 100 miles of improved roads, that along the I. & V. Railway being principally of Spencer limestone, while that closer to the river was of bar gravel. The improved roads of Cass Township are all of the latter material.

The first improved road in the county, built in 1890, was the 10 miles from Bloomfield southwest to Lyons. The old dirt road was followed, and very little grading done. The surface material was wholly bar gravel from White River. On some stretches where the foundation was quite sandy the road is in poor condition, but elsewhere it is yet a good road.

In Richland Township the improved roads have mostly been built with a sandstone base and a top dressing of gravel. The following roads running out of Bloomfield, the county seat, are so constructed:

	Miles.
Worthington road	$3\frac{1}{2}$
Spencer road	4
Wild Cat road	3
Tulip road	3
Park road	7
Salisbury road	$4\frac{1}{2}$
Scotland road	10

Where these roads have been built on a good firm clay foundation and have a thick cover of closely packed gravel, they are fairly good roadways, but not so good as if they had been built of limestone. The Elliston road is wholly of gravel, and in places quite heavy on account of the proportion of sand used.

The eastern 3 miles of the Salisbury road and a number of miles of the road in Center and Jackson townships have been built of the Huron limestone. These roads are hard and durable, but quite uneven and rough in places. This is due to the facts that they were not properly rolled and that the top layer of stone was too coarse. If fine material had been used for the binding

or top layer and a heavy roller passed over each layer several times, the roads would have been far smoother and more lasting. Another fault of construction was the lack of proper shouldering or embanking of the stone, thus allowing it to scatter or spread out on the side. The value and durability of any stone or gravel roads depends as much, if not more, upon the way it is constructed as upon the nature of the material used in its making.

One of the better roads of Greene County is that extending from the Richland Township line to Cincinnati, and running northeast and southeast from the latter point. It has a sandstone base but is heavily top dressed with finely crushed Huron limestone, which has compacted and solidified so that the sandstone can not work its way upward.

MARTIN COUNTY.

Area in square miles	340
Population in 1900	14,711
Miles of public roads	400
Miles of improved roads	65
Percentage of roads improved	16.2
Miles improved with gravel	30
Miles improved with crushed stone	35
Average original cost of gravel roads per mile	$2,000
Average original cost of stone roads per mile	$1,900
Total original cost of improved roads	$125,930
Annual cost of repairs per mile on gravel roads 5 years old	$15
Annual cost of repairs per mile on stone roads 5 years old	$15
Miles of gravel roads built in 1905	None
Miles of stone road built in 1905	14
First improved roads built	1878
Satisfaction of farmers with investment in improved roads	Only fair
Authority	John T. Morris, County Auditor

Near the center of the southwestern fourth of the State is the county of Martin, comprising an oblong strip of territory whose maximum length from north to south is 28 miles, and greatest width 13 miles. It lies south of Greene, east of Daviess, north of Dubois and west of Orange and Lawrence counties.

Three geological epochs are represented in the surface rocks of the county, viz., the Coal Measures and Mansfield sandstone of the Carboniferous and the Huron limestones and sandstones of the Lower Carboniferous periods. The Mansfield sandstone covers at

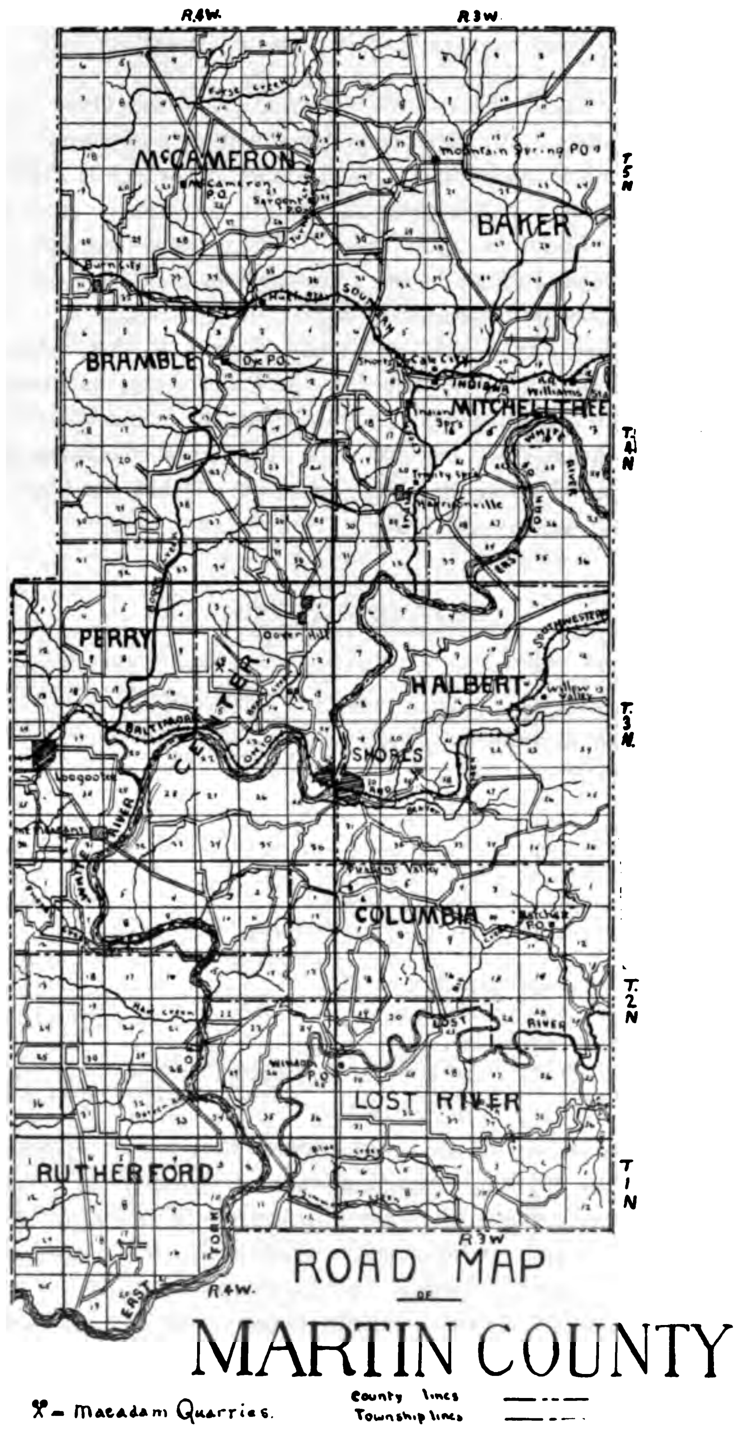

R.4W.
R3W.
McCAMERON
BAKER
BRAMBLE
MITCHELLTREE
PERRY
HALBERT
SHOALS
COLUMBIA
LOST RIVER
RUTHERFORD
T. 5 N
T. 4 N
T. 3 N.
T. 2 N
T. 1 N
ROAD MAP
OF
MARTIN COUNTY
X – Macadam Quarries.
County lines
Township lines

Fig. 52.

least 2-3 of the area, the Coal Measures proper being found only in the southwestern corner and in irregular isolated patches on the tops of the higher hills and ridges of the central portion. The Huron group is mainly confined to the eastern third, though it has been exposed along the streams north of the center and along White River to a point west of Shoals.

With the exception of the extreme northern portion, which is drained by Furse Creek into the West Fork, the entire county is drained into the East Fork of White River. This river is a stream of some importance, having its head in the eastern-central part of the State. It enters Martin County near the middle of its eastern border and flows in many meandering curves to near the southwestern corner, where it turns to the west and forms a small portion of the southern boundary. From the north part of the county it receives Indian and Boggs creeks, while from the eastern and southern portions Beaver Creek and Lost River enter.

By far the greater part of Martin County is within the driftless zone of the State, the massive sandstones and limestones coming everywhere close to the surface. It, therefore, has all the characteristic ruggedness of a region in which these conditions prevail. White River and its main tributaries have been the chief agents in carving the surface rocks into fantastic shapes and plowing those deep gulches and valleys which are so prominent a part of the scenery of the county. In the northern portion, between Indian and Boggs creeks, is an almost continuous ridge from 100 to 250 feet above the valleys. From it project numerous nearly level arms between the branches of the two creeks. East of Boggs Creek the county is so broken that the greater part of it can not be cultivated. South and east of White River the surface is still more rugged than that north of White River, due to the Mansfield sandstone being here more massive and probably thicker. As before, the ridges are narrow on top, the valleys broad. Often the Mansfield sandstone produces high perpendicular bluffs, or nearly as steep slopes, 50 to 100 feet high.

Road Materials.

Nearly ¾ of the area of Martin County is lacking in material suitable for the improvement of the roads. Like Greene, the county lies too far west for the Mitchell limestone and too far south for the drift gravel. The Mitchell stone is exposed in the county only in section 1, Mitcheltree Township, where it outcrops along Indian Creek. It can there be obtained in sufficient quantity to improve many miles of road in Baker and Mitcheltree townships, and is highly suitable for that purpose.

Huron Limestones.—The streams of the eastern half of Martin County have in many places cut through the massive Mansfield sandstone and exposed the underlying rocks of the Huron group. Especially is this true in the eastern half of Baker and the greater part of Mitcheltree townships where, in the bluffs of Sulphur and Indian creeks and their tributaries, as well as those of White River, the Huron sandstones and limestones outcrop. In Brown Township exposures of limestone occur along Boggs Creek and in Center Township north of the river, along Beech Creek and its branches and White River as far down as Shoals.

South of the river numerous outcrops of Huron limestone are found along Beaver Creek, in Halbert Township, and along Lost River and its tributaries in Lost River and Columbia townships. The western portion of the county is, however, wholly lacking in limestone suitable for road purposes.

The Huron limestone available for road metal is usually that of the upper and middle beds, the lower bed not being noted in the county. It is a hard, semi-crystalline bluish-gray stone, which will stand heavy traffic, but will not pack as readily or compactly as the softer Mitchell stone. If the lower portion of the roadbed be composed of pieces less than 2½ inches in size and properly rolled, then covered with 3 or 4 inches of fine pieces, all of which will pass through a 1-inch ring, it will make a road which will last for years. On all the roads which I saw in the county which had been built of it, the pieces of stone were entirely too large, the majority of them being 3½ to 5 inches or more in diameter. The principal reason for this is the almost universal custom there in vogue of breaking or napping the stone on the road by hand rather than breaking with a crusher and hauling thereto. Where a person is breaking with a hammer at so much per cubic yard,

unless he is under careful and strict supervision, most of the stone will be left too large. It is impossible to build a good road from a hard stone of any kind unless it be broken into pieces 2½ inches or less in size.

But two quarries in the county were being worked for road metal at the time of my investigation. One of these was on the land of John Scott, in the southeast quarter of section 10 (3 N., 4 W.), about 3 miles southwest of Dover Hill. Here, on the bluff of a branch of Beech Creek, an outcrop of Huron limestone had been opened to a depth of 14 feet. From 3 to 5 feet of sandstone and soil had to be removed from above the limestone. The latter was in layers ranging from 3 feet down to 4 inches in thickness. It was being quarried out in large blocks, then broken with a sledge into pieces small enough to handle. These were loaded on wagons and hauled 1½ to 3 miles to points on the Dover Hill and Loogootee road where it was being napped for road metal. The owner received 25 cents per cubic yard for the stone in sizes ready for hauling, and the teamsters, at 62½ cents per yard, averaged 4 loads per day. Samples of the stone were taken and tested at the Laboratory of the U. S. Office of Public Roads, the tests resulting as follows:

*Results of Tests of Stone from the land of John Scott, Martin County.**

Specific gravity	2.6	French coefficient of wear	12.4
Weight per cu. ft. (lbs.)	162.3	Hardness	8.5
Water absorbed per cu. ft. (lbs.)	2	Toughness	9
Per cent. of wear	3.2	Cementing value—Dry	18
		Wet	67

"A rock of fair hardness, toughness and resistance to wear and good cementing value. Suited to suburban and highway traffic."—Page.

A chemical analysis of the stone showed its composition to be as follows:

Analysis of Stone from land of John Scott, Martin County.

	Per cent.
Alumina (Al_2O_3)	1.30
Iron oxide (Fe_2O_3)	.75
Lime (CaO)	51.80
Magnesia (MgO)	2.10
Insoluble in hydrochloric acid	2.74
Loss on ignition	41.36
Total	100.20

*For standard of comparison see p. 79.

Two old quarries in the Huron limestone were noted on the west side of the Shoals and Dover Hill road, where the stone for its surface had been obtained. The other quarry in operation was on the land of John B. Lloyd, along one of the tributaries of Beaver Creek, section 29 (3 N., 3 W.). Stone for the Shoals and Weisbach road, 5 miles in length, was in part being taken from this quarry.

With 2 or 3 stone crushers properly located at some of the better exposures of Huron limestone, good and serviceable road material for improving the great majority of the roads in Lost River, Columbia, Halbert, Center, Mitcheltree and Baker townships can be readily obtained and the hauling distance nowhere be greater than 4 miles.

Gravel.—No deposits of drift gravel large enough to be utilized for road improvement occur in the county. The creek and river gravel is of little account, being for the most part pieces of sandstone, shale or limestone derived from the country rock.

There are, however, a number of large deposits of true conglomerate, comprising in part the Mansfield sandstone or Millstone grit, which have been utilized as a top dressing for stone roads and have served the purpose well. This conglomerate is composed of quartz pebbles, ranging in size from a hickory nut down, and firmly cemented by iron oxide. This forms in places thick ledges, which can be broken by dynamite and the pieces then crushed with a sledge. In dry, warm weather it can be easily worked, but when placed on a road and exposed to rain it quickly packs and cements. It can not be worked in winter, as the frost and moisture cause it to cement very closely almost as soon as broken.

Two deposits of this conglomerate gravel have been extensively used. One of these, on the land of Samuel Cottingham, near Hickory Ridge Schoolhouse, northeast quarter section 13 (3 N., 4 W.), between Shoals and Dover Hill, was visited. Here the exposure is in the form of a bold ledge, 80 yards long and 20 feet in thickness. Several large piles of the conglomerate, which had recently been dynamited down and crushed into its component parts of quartz pebbles and iron oxide, were awaiting the haulers. The owner receives 25 cents per yard for the material ready for the roads. Being used at present only for repair of the surface

Plate XV.

Outcrop of Conglomerate Gravel on land of Samuel Cottingham, three miles north of Shoals. Used extensively as top dressing for roads.

Stretch of Shoals and Loogootee road, built wholly of Conglomerate Gravel.

of the improved roads of the vicinity, the annual sale is not large, probably running 500 to 700 yards per season. Many thousand cubic yards are, however, available. A sample was taken from the Cottingham bank and sent to Washington, D. C., for testing at the Road Material Laboratory. It was reported on as follows: "Dry grinding cementing value, 4; wet grinding value, 20. A gravel which develops a fair cementing value on wet grinding."—Page.

Broken quartz or quartz pebbles are by themselves nearly useless as a road material on account of their hardness and total lack of binding power. Shaler says of them, after speaking of other forms of gravel: "Where the gravel is composed mainly of white quartz, because of the smoothness and slight binding power of the quartzose bits the material is of much less value. Wherever these white quartz pebbles constitute more than half the mass it is usually worthless as a covering for roads. It can be made serviceable only by the admixture with it of some binding material, such as iron ore."* While the quartz pebbles in this conglomerate make up half or more of its bulk, the cementing or binding material is already present in quantity in the form of iron oxide. Where used as a top dressing over the Huron limestone, the surface is smooth, compact and seemingly fully up to the average of that produced by drift gravel or smaller pieces of the limestone. The great trouble with most of the roads on which it has been used is that they have not been properly constructed, the under layers of stone being too coarse and the conglomerate gravel being dumped without embankment of earth to keep it from spreading. As a consequence, much of the gravel has been lost by being washed or worked out into the side ditches.

Thousands of cubic yards of an excellent grade of this gravel occurs in ledges along the north side of the B. & O. S.-W. Railway, 1 to 3 miles west of Shoals, on lands belonging to John B. Lloyd and James Guthridge. These ledges occur some 20 to 50 feet above the railway grade and in many places are so exposed that they can be readily broken and reduced into the gravel, ready for the roadway.

Another large deposit, or rather outcrop, of the gravel which

*American Highways, p. 66.

has been drawn upon extensively for top dressing material is on the land of Valentine Barthel, section 2 (2 N., 4 W.), near Beech Grove Schoolhouse, 3 miles southwest of Shoals.

IMPROVED ROADS.

The old New Albany and Vincennes road, discussed in section 1 of this report, runs east and west through Martin County, about 2 miles south of Shoals, the county seat. It was graded and bridged by the State in 1837-38 as far west as Mt. Pleasant, near the western edge of the county and then the county seat. It passes through the hamlets of Independence and Pleasant Valley and in the eastern part of the county is very rough, with many steep grades. East of Pleasant Valley, about 5 miles of this road has been recently improved (?) with broken sandstone and a top dressing of branch gravel. The broken sandstone has already in many places worked its way up through the gravel and made the roadway very rough. The gravel being largely sandstone and limestone in nature, will not wear long before the road is full of ruts.

In Lost River Township in the southeastern corner of the county and Rutherford in the southwestern corner there is not a mile of improved road. An election was held in Lost River Township in the spring of 1905 to vote on the question of making graded roads, without a metal covering, but the project was defeated. In Rutherford Township there has, as yet, been no agitation of the improved roads question, the residents being content to travel the same rough roadways their fathers have trod.

In Center Township the road from West Shoals to Dover Hill, a distance of nearly four miles, has been improved with Huron limestone, covered for most of the way with a top dressing of conglomerate gravel. A spur of this road, about 1½ miles in length, running west towards Loogootee from the top of the hill, has also been improved with limestone and gravel. In most places these two roads are in fair condition. Their most serious fault is a roughness in places, due to the use of large stone, all of it being 3 inches and over. The side ditches have not been kept open properly, and as a consequence the roadway has been badly washed on a number of the grades. On the side road mentioned there is

a stretch of almost ½ mile built wholly of the conglomerate gravel. It has been used 5 years, is very smooth and firm and is said to be free from ruts at all seasons of the year. Not being properly embanked, the heavy rains have in places washed a quantity of the gravel into the ditches. From the appearance of this road I would judge the gravel to be well adapted for use on country roads with a medium or light traffic.

South of West Shoals, the Shoals, Mt. Pleasant and Loogootee road, eight miles in length, is of Huron limestone. About one-half of the road has the same limestone as a top layer, the other half gravel from the Barthel pit.

The Shoals and Weisbach road, five miles in length, under construction at the time of my visit, was being covered with Huron limestone. The accompanying view of a portion of the completed road from a photograph taken by me tells better than words the quality of the road. The rock was broken by hand on the road, and if any of the pieces were less than four inches in diameter I did not see them. There was little grading, no top dressing and no rolling, yet the road was to cost $1,800 per mile.

The Sampson Hollow road, southeast of Shoals, about three and a half miles in length, is in part of limestone covered with branch gravel and the remainder of sandstone with gravel cover. The limestone portion is a fairly good road, but that with a sandstone base is a failure. It has been built less than two years, and is already gullied into ruts along the wheelways. It will last but a few years under light traffic, yet it cost $1,400 per mile.

The Huron system, comprising seven miles north and northeast of Shoals, is one of the best roads in the county. It is built wholly of Huron stone, the upper layer being of finer material and binding well.

In Mitcheltree township the road from Trinity Springs north to the township line and two prongs, aggregating about 12 miles, are of limestone with a conglomerate gravel top, the material for the latter being secured from a ledge about one and a half miles east of Trinity Springs.

In neither Brown nor McCameron townships are there any improved roads, or any building. In Baker Township, in the northeast corner of the county, the five-mile stretch from Cale to Mountain Springs has been improved with Huron limestone.

Plate XVI.

Showing a section of the Shoals and Weisbach road as completed. The stone was broken by hand and the pieces were three or four times too large. The surface is very rough and uneven and will not be compacted by travel.

Section of unrolled macadam stone road, built of Huron limestone, near French Lick, Orange County. The stone on this road was broken by machinery and is much finer than that shown on the road above. The road could have been much improved by rolling with a heavy steam roller. (See p. 928.)

In Perry Township, in which Loogootee, the largest town of the county is located, about 25 miles have been improved. The roads running southeast to Mt. Pleasant, south to Whitfield and north to Burns City, in all about 19 miles, have been graveled with material shipped in from Greene County. They were not properly graded and drained and when heavy rainfalls came much of the gravel went down into the mud. They are everywhere better than mud roads, and in some places much better, but that is as much as can be said for them. A macadam road from Loogootee to Dover Hill was being constructed from Huron limestone, the material being napped on the road.

While Martin County in the last seven years has made a good start toward the improvement of her roadways, she has, in few instances, gotten what she should have for the money invested. Inexperience, poor grading, no rolling and coarse stone have been the chief causes which have led to this result. While the roads are far better than they were when improvements began, an experienced roadmaster, who would have used strict supervision over their construction, would have doubled the lease of life which most of them will possess.

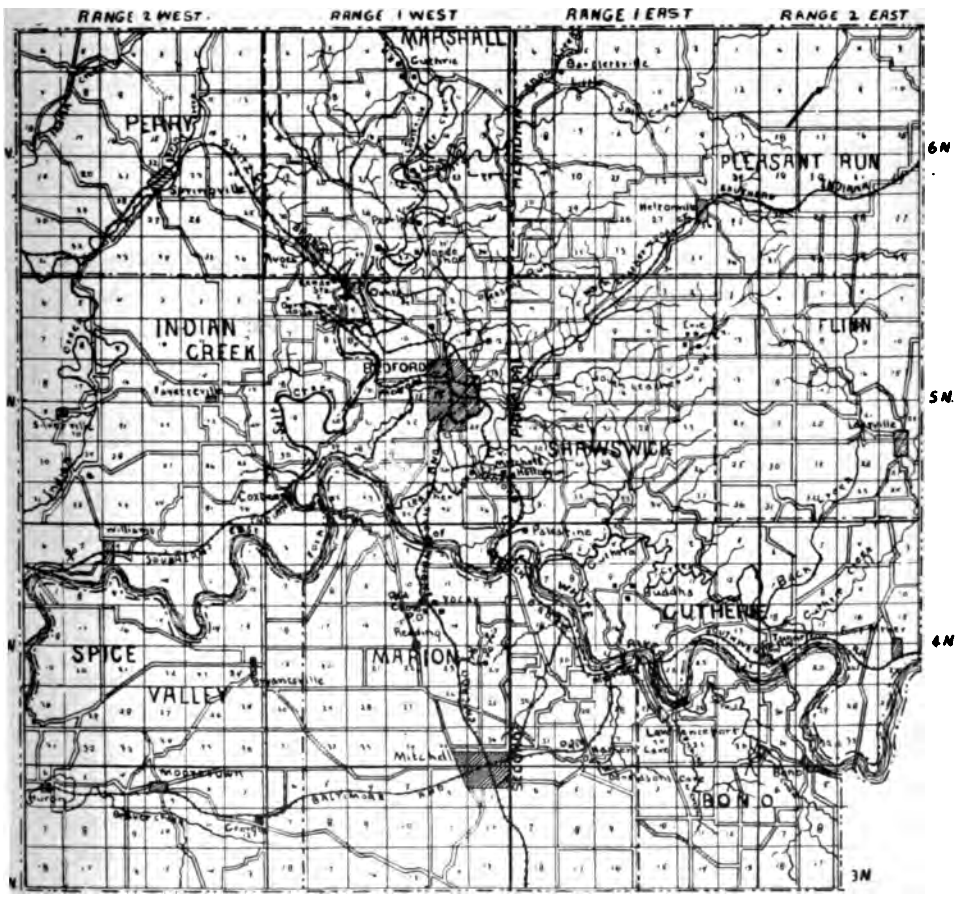
LAWRENCE COUNTY.

Area in square miles	454
Population in 1900	25,729
Miles of public roads	600
Miles of improved roads	350
Percentageof roads improved	58.3
Miles improved with gravel	275
Miles improved with crushed stone	75
Average original cost of gravel roads per mile	$1,500
Average original cost of stone roads per mile	$1,900
Total original cost of improved roads	$555,000
Annual cost of repairs per mile on gravel roads 5 years old	$60
Annual cost of repairs per mile on stone roads 5 years old	$60
Miles of gravel road built in 1905	35
Miles of stone road built in 1905	15
First improved roads built	1895
Proportion of improved roads built since 1895 (per cent.)	66⅔
Authority	Walter G. Owens, County Auditor

Lawrence County is situated in the south central part of the State, 75 miles southwest of Indianapolis. It lies south of Mon-

roe, west of Jackson and Washington, north of Orange and east of Martin and Greene counties. In outline it is nearly square, being 22 miles in width from east to west and 21 miles in length. It is wholly within the driftless area of the State.

The rocks forming the surface of the county represent six geological epochs. The Knobstone covers the northern half of the



ROAD MAP
OF
LAWRENCE COUNTY

County lines
Township lines

X = Macadam Quarries.

Fig. 53.

northeastern fourth and a narrow strip along the eastern border. The Harrodsburg limestone forms the greater part of the eastern half, and where eroded through by the streams, has exposed the underlying Knobstone in a number of the valleys. The famous Bedford Oölitic limestone covers a narrow, irregular strip just to the west of the Harrodsburg. The Mitchell limestone occurs over the surface of a strip three to nine miles in width extending from northwest to southeast, just west of the center, the wider portion being in the area south of White River. The Huron Group covers large areas in the northwestern and southwestern portions, while the Mansfield sandstone forms the surface of some of the higher elevations in the extreme southwestern corner.

On account of the presence of so many rock formations, the surface of the county is exceedingly diversified. The eastern and northeastern parts are undulating or gently rolling plateaus drained by deep, narrow valleys, the central region north of White River is hilly, and the western and southwestern is rough and broken. Each of these divisions is covered with a soil almost wholly formed from the decomposition of underlying rocks. We consequently find the soil in the first tenacious clay and sand; of the second, a calcareous clay, and of the third, principally siliceous material, with an intermixture from both of the others. In that part of the county underlain by the oölitic and the Mitchell limestones, comprising a broad belt about 12 miles wide, passing centrally from northwest to southeast, sink holes are so numerous as to form a striking feature in the configuration of the surface.

The East Fork of the White River, which, with its tributaries, drains the entire county, crosses the county from east to west in a very meandering course a little south of the center. It is a broad, clear stream, as large as the Wabash at Lafayette, and flowing with a rapid, strong current. From the north it receives Indian, Salt, Leatherwood and Guthrie creeks, while from the south enter Sugar, Fishing and Beaver creeks.

Road Materials.

Lawrence County is rich in materials suitable for the improvement of her roads. That the people are beginning to find this out and to appreciate it is shown by the fact that over one-half of the public roads have been macadamized or graveled since 1895.

That gravel is preferred to stone as a surface covering is also shown by the fact that 275 miles of gravel roads exist, as against 75 of crushed stone.

Harrodsburg Limestone.—This stone lies to the east of the oölitic, and comes to the surface as the country rock over the greater part of Flinn, Shawswick and Guthrie townships, and also over portions of Pleasant Run, Marshall and Bono townships. Many exposures occur along the streams and ravines of the townships mentioned. It consists mainly of a series of strata of light drab to dark blue limestone, some of which are composed very largely of bryozoa, while others appear to be made up of finely comminuted crinoid stems and shell fragments. Intercalated with the lower layers are thin beds of shale, which contain many geodes. The thickness of the Harrodsburg formation as exposed ranges between 25 and 60 feet, the average in the county being about 40 feet.

While the Harrodsburg limestone is not as durable a road metal as the Mitchell, it is far superior to the oölitic or to any sandstone or shale for that purpose. It has been, as yet, but little used in the county, as the roads within the areas which it covers have been, for the most part, built of gravel, of which it is the main source.

Oölitic Limestone.—This well known and easily worked building stone has its principal development in Lawrence and Monroe counties. In the former it occupies a narrow, tortuous strip just to the west of the Harrodsburg, in Marshall and Shawswick townships, and also caps a number of the ridges to the east, northeast and southeast of Bedford. It is too soft and easily pulverized to withstand traffic on any but little-traveled country roads.

Mitchell Limestone.—A broad area of this excellent road metal stone extends from northeast to southwest through the center of the county. It forms the greater part of the country rock in western Marshall, eastern and southwestern Perry and the greater part of Indian Creek townships. South of White River it outcrops over a broad area from near Huron Station on the west to several miles east of Mitchell. It is typically developed in the vicinity of Mitchell, in Marion Township, and from that town its name is derived. Large isolated areas also occur in Shawswick Township around Bedford, and to the southeast of that city.

As has been stated, the Mitchell limestone is one of the best

road metal stones in the State. In Lawrence County its lower strata consists of yellow, drab or gray limestone, while the upper portion is a compact, blue or gray limestone, with intercalated thin beds of shale and considerable gray chert. In places it runs up to 150 or more feet in thickness.

One of the best exposures of the Mitchell stone in Lawrence County is that at Rock Ledge, west half of section 11, one and three-tenth miles west of Williams, a station on the Southern Indiana Railway. Here a quarry has been operated since 1898 by the railway company, a large crushing plant having been installed for making ballast and macadam.

In September, 1905, the quarry exposure was 91 feet in height. Above the top layers of the Mitchell stone were one to three feet of clay and soil and three to four feet of Huron sandstone. Both have to be removed when road material is being crushed, but the sandstone is left when the output is used for ballast. The layers of the Mitchell stone run from 8 inches to 12 feet in thickness. The lower 14 feet of the face of the quarry is semi-lithographic in character, being very fine-grained, and breaking easily with a conchoidal fracture. The upper portion of the stone is tougher and more difficult to spall. The rock is mostly gray, shading into blue in places, and showing thin but irregular seams of blue clay between a number of the layers. Chert nodules occur scattered through the upper portion. The company owns 30 acres surrounding the quarry, over which the Mitchell stone averages 80 to 90 feet in thickness. Average samples of stone from this quarry were tested at the Road Testing Laboratory at Washington, D. C., the results of the tests being as follows:

Results of Tests of Mitchell Limestone from quarry at Rock Ledge, Lawrence County.

Specific gravity.................	2.7	French coefficient of wear.	9.7
Weight per cu. ft..........(lbs.)	168	Hardness.................	12
Water absorbed per cu. ft..(lbs.)	.7	Toughness................	8
Per cent. of wear..............	4.1	Cementing value—Dry....	34
		Wet....	141

"A hard rock with a fair toughness and resistance to wear, and an excellent cementing value. A good, all-around road material."—Page.

Other excellent exposures of the Mitchell stone which have been worked extensively for lime, macadam and cement-making

purposes occur near Mitchell. The best known of these is on Rock Lick Creek, northeast quarter of section 24 (4 N., 1 W.), where the Mitchell Lime Company operates a large quarry and plants for burning lime and crushing and grinding the stone for road-making, ballast and other purposes.

In September, 1905, the face of the quarry was 44 feet 6 inches in height. From above this 5 to 7 feet of soil and clay had been removed. The stone is in 9 to 11 layers, which vary in thickness from 10 inches to 5 feet. The stone is quite tough and difficult to grind; and it is said that the drier it gets the tougher it becomes. The edges of the macadam made from it are rounded rather than sharp. It packs well and makes a hard and durable surface. Samples from this quarry tested at Washington showed the following results:

Results of Tests of Mitchell Limestone from the quarries of the Mitchell Lime Company, on Rock Lick Creek, Lawrence County.

Specific gravity	2.6	French coefficient of wear	8.8
Weight per cu. ft. (lbs.)	162.2	Hardness	4
Water absorbed per cu. ft. (lbs.)	1.66	Toughness	9
Per cent. of wear	4.6	Cementing value—Dry	28
		Wet	26

"Above the average in hardness for limestone and about the average in toughness and resistance to wear. Cementing value fair. Best suited for highway and country-road traffic."—Page.

The analysis of the stone by the chemist of the Road Testing Laboratory showed its constituents to be as follows:

Results of Analysis of Mitchell Limestone from quarries of the Mitchell Lime Company, on Rock Lick Creek, Lawrence County.

	Per cent.
Alumina (Al_2O_3)	Trace
Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	55.05
Magnesia (MgO)	Trace
Insoluble in hydrochloric acid	1.86
Loss on ignition	43.06
Total	99.97

From near Georgia to beyond Fishing Creek the Mitchell stone forms the top and upper portion of the hills overlying the Bedford oölitic limestone which outcrops at the base of the hills. In

the upland area around Mitchell there are large quantities of chert fragments scattered through the reddish brown clay soil, which have been derived from the decay of the upper portion of the underlying Mitchell stone. Besides the larger quarries above mentioned, numerous smaller ones are scattered throughout the Mitchell area of Lawrence County, which are used locally for macadam, well curbing, foundations, bridges, etc. Similar quarries, which will yield unlimited quantities of excellent road metal, can be opened on the side of almost every ravine or creek bluff in the area mentioned.

Huron Limestone.—The Huron group of rocks form the surface of the hills and ridges over large portions of the western third of the county. The limestones of the group, three in number, can be drawn upon for large quantities of road metal, should necessity require, which is not likely in a region where the more available and better Mitchell limestone is so abundant. However, for most of the roads of Spice Valley Township the Huron will be the cheaper stone to use, as the Mitchell occurs near the surface only in the area between Bryantsville and White River. The properties and qualities of the Huron stone for road metal have been fully discussed on previous pages.*

Gravel.—The creek gravels of eastern Lawrence County have been extensively used for road improvement. As already noted, these gravels have been derived for the most part from the Harrodsburg limestone and the Knobstone shales, and consist largely of small geodes, chert nodules and other hard material, with enough iron oxide, angular pieces of limestone and red clay intermingled to cause them to cement quickly and firmly under traffic. Almost all the improved roads north of White River and east of the Monon Railway have been built of this gravel.

Mr. G. C. Houston, city engineer of Bedford, who has had a wide experience in superintending the construction of improved roads, claims that the Leatherwood Creek gravel is the best road material in Lawrence County; that roads constructed of this gravel last longer than stone roads, are smoother and less liable to become filled with ruts along the wheelways. Leatherwood Creek and its tributaries extend into the heart of the Harrodsburg limestone

*See p. 143.

area of the county, and the bars of these streams have furnished the material for the majority of the gravel roads. The supply is in places limited at times, but new bars are formed after every freshet, as the streams are fed from ravines and gullies, down which the debris of the decaying Harrodsburg stone is washed by every rainfall. The farmers along Leatherwood Creek get 10 cents a yard for the gravel for road purposes. A sample taken by Mr. Houston from a bar on Leatherwood was evidently below the average in cementing constituents as, when tested at the road laboratory at Washington, D. C., it showed a dry cementing value of only 2, while its wet value was 12. Of it Mr. Page wrote: "A gravel of rather low cementing value. Should not be used if a higher binding material is available."

Other streams along which the same character of gravel occurs in quantity are the head waters of Salt Creek in the northern part of Pleasant Run Township, and Back and Guthrie creeks in Flinn and Guthrie townships. The gravel usually occurs in bars in the streams, which are readily available at low water. In the overflowed bottoms these bars are often found covered with alluvial soil, and the latter is stripped to get at the gravel.

Extensive gravel bars also occur in White River, but they are largely composed of limestone and shale fragments and are therefore much inferior to the creek gravel for road purposes. No deposits of drift gravel occur in the county.

Improved Roads.

From the statistics given at the head of this chapter it will be seen that the citizens of Lawrence County are fully alive to the importance of the gravel road question. To improve nearly 60 per cent. of the public roads of the county in ten years is a record of which they may well be proud, and one which some of the other counties of southern Indiana which have abundant road materials would do well to imitate. Moreover, the majority of the roads have been built under the supervision of men of experience and the taxpayers have gotten fair returns for their money.

With the exception of one or two roads of river gravel in Bono Township, all the roads south of White River have been built of Mitchell limestone. North of the river, those west of the Monon

ute. The stone is then dynamited down and loaded into cars, which are elevated by steam power to the level of the l crusher. From this the broken stone is elevated and p through a 12-foot rotary screen with ½, 1½ and 2½-inch ings. What does not pass through these openings is returne passes through the smaller crusher. About 60 men are emp in the quarry and at the plant, the average wage for common being $1.40 per day.

The macadam is dumped from bins into cars and sells a cents per ton at the plant, a cubic yard, after screening, wei about 2,400 pounds. Large quantities of the stone are also gr into a fine powder for glass making and fertilizer purposes. the latter use it is shipped mainly to Illinois, where it serv correct the acidity of the soil. This ground stone brings per ton at the plant.

In addition to the plants mentioned, the Lehigh Portland ment Company operates three Gates crushers at their quar half mile north of that of the Mitchell Lime Company. are Nos. 9, 7½ and 2, respectively. The Mitchell stone is cr at this quarry only for use in Portland cement manufacture

ORANGE COUNTY.

Area in square miles	
Population in 1900	
Miles of public roads	
Miles of improved roads	
Percentage of roads improved	
Miles improved with gravel	
Miles improved with crushed stone	
Average original cost of gravel roads per mile	
Average original cost of stone roads per mile	
Total original cost of improved roads	$2
Annual cost of repairs per mile on gravel roads 5 years old	
Annual cost of repairs per mile on stone roads 5 years old	
Miles of gravel road built in 1905	
Miles of stone road built in 1905	
Miles of gravel road contracted for 1906	
Miles of stone road contracted for 1906	
First improved roads built	
Satisfaction of farmers with investment in improved roads—	"More than ple
Authority	Alvin B. Ham, County A

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ute. The stone is then dynamited down and loaded into tram-cars, which are elevated by steam power to the level of the larger crusher. From this the broken stone is elevated and passes through a 12-foot rotary screen with ½, 1½ and 2½-inch openings. What does not pass through these openings is returned and passes through the smaller crusher. About 60 men are employed in the quarry and at the plant, the average wage for common labor being $1.40 per day.

The macadam is dumped from bins into cars and sells at 50 cents per ton at the plant, a cubic yard, after screening, weighing about 2,400 pounds. Large quantities of the stone are also ground into a fine powder for glass making and fertilizer purposes. For the latter use it is shipped mainly to Illinois, where it serves to correct the acidity of the soil. This ground stone brings $1.50 per ton at the plant.

In addition to the plants mentioned, the Lehigh Portland Cement Company operates three Gates crushers at their quarry, a half mile north of that of the Mitchell Lime Company. These are Nos. 9, 7½ and 2, respectively. The Mitchell stone is crushed at this quarry only for use in Portland cement manufacture.

ORANGE COUNTY.

Area in square miles	400
Population in 1900	16,854
Miles of public roads	700
Miles of improved roads	168
Percentage of roads improved	24
Miles improved with gravel	40
Miles improved with crushed stone	128
Average original cost of gravel roads per mile	$1,250
Average original cost of stone roads per mile	$1,800
Total original cost of improved roads	$280,000
Annual cost of repairs per mile on gravel roads 5 years old	$30
Annual cost of repairs per mile on stone roads 5 years old	$50
Miles of gravel road built in 1905	1
Miles of stone road built in 1905	30
Miles of gravel road contracted for 1906	3
Miles of stone road contracted for 1906	21
First improved roads built	1897
Satisfaction of farmers with investment in improved roads—	"More than pleased"
Authority	Alvin B. Ham, County Auditor

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Authority......... ....Alvin B. Ham, County Auditor

Orange County occupies a place in the second tier of counties north of the Ohio, about 85 miles southwest of Indianapolis. Lawrence County forms its northern and Crawford its southern boundary. Washington and Crawford bound it on the east and Martin and Dubois on the west. The county is square in outline, being 20 miles in length by 20 in breadth.

The Mitchell limestone forms the surface of the eastern two-thirds of the northern half. The Huron limestones and sandstones cover the southern third and part of the northwestern fourth, while the Mansfield sandstone occurs on the higher ridges in the southwestern and northwestern portions.

The northeastern part of the county, embraced in the Mitchell limestone area, is comparatively level, but the topography is varied by the numerous sink holes and basins characteristic of that formation. The southern, central and especially the western parts of the county are very rugged and broken. High and steep ridges, with narrow winding valleys, are the prevailing surface features. Mount Arie, near West Baden, and Burtin Hill, southwest of French Lick, are two of the highest points in this region. Two streams, Lost River and Patoka River, with their tributaries, drain the county. Their general course is from east to west, but very meandering, the former across the northern and the latter across the southern thirds.

Road Materials.

The northern half of Orange County is abundantly supplied with material suitable for building the best of improved roads, and the great majority of the mileage of such roads is in that portion of the county. In the southern half the roal material is, in most localities, limited to the Huron limestone, though in Southeast township there are numerous exposures of the Mitchell stone.

Mitchell Limestone.—This well known macadam material forms the country rock in Northeast, Orleans, Orangeville and the greater part of Paoli and Stamper's Creek townships. On the higher hills and ridges of the last two townships it is capped with Huron sandstone. The Mitchell stone is easily available almost everywhere in the three first mentioned, lying close to the surface and being exposed in many ravines and the bluffs of all streams.

The Mitchell stone is here, as elsewhere, a compact, even-bedded, gray to blue, fine-grained, calcium carbonate, breaking usually with a conchoidal fracture. The upper three to seven feet usually contains numerous chert nodules, which by decay and erosion of the limestone are often left as component parts of the red clayey soil or surface covering. In thickness the entire formation ranges between 50 and 90 feet.

Numerous abandoned quarries of Mitchell stone occur along the improved stone roads where the metal for their surfacing has been obtained. In October, 1905, but three quarries were being worked in the Mitchell stone for macadam material. Of these, two were visited. The first was by the roadside at the east end of the new steel bridge on the Monon Railway, one-half mile northeast of Paoli. Here a quarry had been recently opened in an exposure of the Mitchell stone to secure material for repairing the Paoli and Orleans macadam road. The face of the quarry was but ten feet in height, with but eight inches to a foot of necessary stripping above. The stone was in nine layers, ranging in thickness from two inches to one foot, and was easily quarried and broken. A force of ten men were at work getting out and crushing the stone. About 50 cubic yards daily were produced on an Indiana road machine operated by a traction engine. Thousands of cubic yards of macadam can be readily obtained at this point, and others in the near vicinity.

The second quarry visited was in the northeast quarter of section 27 (3 N., 1 W.), about two and a half miles northwest of Orleans. Here in the side of a large sink hole a quarry had been recently been opened to secure macadam for building two miles of stone road, running north and south past the quarry. The Mitchell stone was exposed to a depth of 12 feet, with but 6 or 8 inches of stripping above. The stone was much whiter and a little softer than other exposures of the Mitchell stone noted, but otherwise appeared well suited for road construction. The contractor, Mr. O. P. Turley, was receiving $1.00 per cubic yard, or $1,462 per mile, for crushing and placing the stone on the road. He paid $50 to the owner of the land for the stone, with the privilege of hauling over the land about 100 yards to the road. He had just completed a contract of three miles on the same terms—i. e., $1.00 per yard for getting out and hauling the stone, he paying $25 per

mile for the stone privilege from the land owner. For hauling he was paying $2.50 per day for teams, and was working 15 to 35 men in the quarry and at crusher, at an average wage of $1.50. He stated that the Mitchell stone varies much in toughness and difficulty of working. At the quarry just opened he had used but 75 pounds of dynamite in securing enough stone for half a mile of road. At the former quarry worked, about two and a half miles south, he used 1,000 pounds in securing stone for the three miles.

Lying as it does so close to the surface, the Mitchell stone offers throughout most of its area in Orange County an easily available and durable road material; and every road within the area should be improved in the near future.

Samples were taken from the quarry northwest of Orleans and tested in the U. S. Road Laboratory at Washington, the tests resulting as follows:

*Results of Tests of Mitchell Limestone from quarry two and a half miles northwest of Orleans.**

Specific gravity	2.5	French coefficient of wear	9.1
Weight per cu. ft. (lbs.)	155.9	Hardness	8
Water absorbed per cu. ft. (lbs.)	3	Toughness	5
Per cent. of wear	4.4	Cementing value—Dry	11
		Wet	37

"A hard and fairly tough limestone, with average resistance to wear, and fairly good cementing value. Best suited for light highway and country-road traffic."—Page.

An analysis of the same stone showed its chemical composition to be as follows:

Analysis of Mitchell Limestone from quarry two and a half miles northwest of Orleans.

	Per cent.
Alumina (Al_2O_3)	.75
Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	56.00
Magnesia (MgO)	Trace
Insoluble in hydrochloric acid	.40
Loss on ignition	43.23
Total	100.38

*For standard of comparison see p. 79.

Huron Limestones.—The Huron limestones offer an abundance of material for road construction in western and southern Orange County. Their general character and fitness for such purpose has already been mentioned.* One or more of the three Huron limestones are exposed in almost every ravine or creek bluff in Northwest, French Lick, Jackson, Greenfield and Southeast townships, and in the south halves of Paoli and Stamper's Creek, and the west half of Orangeville townships.

The only worked quarry visited was on the farm of Lee Henson, one and a fourth miles east of French Lick, where macadam stone was being secured for improving three and a half miles of the French Lick and Paoli road. At the quarry, which was near the crest of a ridge in the northeast quarter of section 2 (1 N., 2 W.), the hard, blue, semi-crystalline middle Huron stone was opened to a thickness of 14 feet. It was in seven layers, ranging from 9 inches to 6 feet in thickness, with a surface stripping of one to two and a half feet. This stripping was mostly soil and clay, though remains of a thin layer of sandstone occurred in places. The limestone was readily quarried, breaking freely with a hammer. The land owner was paid $25 per mile of road for the stone used. A National jaw-crusher, with eight-foot revolving screen and Ingersoll steam drill, were used.

Where the Huron stone is broken to the proper fineness, it seems to pack well, though no steam roller was being used on the roads in course of construction. The contractors—Smith Bros. of French Lick—had just completed three and a half miles to the south of that town, in which the same limestone was used.

Gravel.—In the northeastern part of Orange County, notably along Lost River and its tributaries in Orleans and Northeast townships, occurs a creek gravel which has been used extensively in road building. It is composed largely of chert nodules from the upper portion of the Mitchell stone, and small geodes from the Harrodsburg limestone to the east, combined with enough red clay and particles of iron carbonate to cause it to pack firmly and make a road surface equal in smoothness and durability to that of any gravel road which has come to the writer's notice in the State. A sample of this gravel was secured from a bar of Lost River on

*See p. 143 of this report.

the land of Cyrus Finley, just above the Finley ford, three and a half miles southeast of Orleans, and tested at Washington, the results of the test showing its dry grinding cementing value to be 19, as against 82 for the average of 59 samples of gravel previously tested at the laboratory, and its grinding value 58. Of it Mr. Page wrote as follows: "A gravel with good cementing value; will do well for gravel roads or as a binder." About 40 miles of roads have been improved from the bars of Lost River and new bars are constantly forming each year. The stream gravel in the southern part of the county, as well as that about French Lick, in the northwestern portion, is of no value for roads, as it is largely composed of fragments of the Huron and Mansfield sandstones, which quickly grind into dust.

Improved Roads.

The majority of the 168 miles of improved roads of Orange County have been well constructed of good material, and are proving an investment with which the farmers are "more than pleased." The first improved road in the county was the old New Albany and Paoli turnpike, finished by the State in 1839,* and later turned over to a private corporation, which operated it as a toll road until 1897, when the eleven miles of it in Orange County were purchased for $1,000 per mile and made free. It was macadamized mostly with Mitchell limestone secured from alongside its course and napped by hand on the road. The first free improved road constructed under the present law was the Orleans and Paoli pike, built in 1897 on the same plan, the road metal being placed in three layers and all broken by hand. The first layer, four inches thick, was composed of stone four or five inches in size. The second layer, three inches thick, was of stone three inches in size, and the top layer, three inches thick, of finer stone. The road was ten feet wide, and on level ground is yet in good condition, but the drainage on the inclines was not sufficient, the ditches being too shallow, and in such places the road has been badly washed each year. A heavy rainfall in September, 1905, in many places washed great gullies through the center of the road and exposed in others the large stone at the bottom. The citi-

*See p. 33 of this report.

zens profited by experience, and all stone roads are now being built with better grades, better drainage and with stone crushed by machinery. The grades are built 14 to 16 feet in width, with the macadam 10 feet wide and well embanked on each side.

When the first elections for improved roads were held in the county there was strong opposition, the farmers having exaggerated ideas of their cost, and the elections were carried by a bare majority. Now from 65 to 85 per cent. of the total vote is cast in favor of road improvement.

In Southeast Township there is not yet a mile of improved road, but a contract has been let for improving the Paoli and Leavenworth road with stone in 1906. North of Valeen the road runs along a narrow ridge and stone can be gotten from the slope on either side.

In Greenfield Township there is not a mile of improved road, and none under consideration, though Huron limestone is abundant. In Jackson Township the contract is let for improving the French Lick and Newton Stewart road with Huron limestone as far as the 4 per cent. levy will permit.

In French Lick Township seven miles were improved with Huron stone in 1905, Smith Bros., the contractors, building three and a half miles of the Unionville road for $1,920 per mile and three and a half miles of the French Lick and Paoli road for $1,980 per mile. Two layers of three-inch stone, each three inches thick, were covered with a top layer, also three inches thick, of one-inch stone. All the principal roads radiating from French Lick and West Baden are now improved with stone.

In Paoli Township there are eleven pike roads constructed of Mitchell stone either leading into Paoli or connecting with one another just outside the town. The Orleans and Paoli road, the first built, is one of the poorest in the county.

In Stamper's Creek Township the road east and west through Millersburg to the Washington County line is of stone, and one other is building south of Millersburg.

The roads of Northeast Township are all of the creek gravel of Lost River and excellent in character. In many instances the gravel was hauled three to five miles over Mitchell stone, but as the stone lies deep, with heavy stripping, the gravel was considered the cheaper.

In Orleans Township most all roads are improved, 40 per cent. with gravel and 60 per cent. with stone. On two or three of the roads the base of the surface is of stone and the top dressing of creek gravel, a combination which seems successful. The Orleans and Livonia all-gravel road is one of the best in the State, the surface very smooth, well packed, a brownish yellow in color, with little dust in dry and no mud in rainy season. Some of these gravel roads, for example the Lancaster and Valeen roads, are six years old and have required little if any repairing. These roads are, however, mostly on level land, and might not prove so smooth and durable were they in the broken region to the west or south. The two miles of stone road built in 1905, west of Orleans, cost $1,700 per mile. Neither the grade or drainage is all that it should be, and no roller was used in compacting the stone. Otherwise it was very well constructed.

In the northern part of Orangeville Township one and three-quarter miles of stone road was being constructed in October at a cost of $1,250 per mile. The stone was all of one size, the surface to be nine inches thick and nine feet wide. The estimate had been placed too low and the contractor threw up his job, it being afterward finished by the residents along the line. Four miles of the Orleans and Orangeville road was built for $1,350 a mile, the basal stone being four inches in size and the top layer one and a half inches.

In Northwest Township the West Baden and Huron road, running north and south across the township, is of crushed stone.

Mr. O. P. Turley, the contractor above mentioned as crushing stone for a road in Orleans Township, has an excellent portable outfit for producing macadam. He kindly gave me the cost of the same as follows:

No. 4 Austin jaw-crusher, including rotary screen and elevator.....	$900
Ingersoll steam drill..	300
16 H. P. Huber traction engine....................................	1,750

The engine runs both crusher and drill. The former has a capacity of 200 yards of macadam daily, but only from 125 to 135 yards were being produced. The screen is eight feet long, with one and a half to two and a half-inch openings, each sized opening being over a separate bin. To the prices above given the freight must be added.

All in all, Orange County is to be congratulated on the excellent beginning she has made in solving the good roads problem. If in the future a little more care be given to grading and drainage and a heavy steam roller be used on each layer of stone or gravel, the roads will be so much the better and more lasting. It is to be hoped that the good work will continue until every road of any importance in the county will be permanently improved.

WASHINGTON COUNTY.

Area in square miles	523
Population in 1900	19,409
Miles of public roads	1,500
Miles of improved roads	113*
Percentage of roads improved	7.5
Miles improved with gravel	8
Miles improved with crushed stone	105
Average original cost of gravel road per mile	$900
Average original cost of stone road per mile	$2,000
Total original cost of improved roads	$183,200**
Annual cost of repairs on gravel roads 5 years old	$50
Annual cost of repairs on stone roads 5 years old	$100
Miles of stone road built in 1905	20
Miles of gravel road contracted for 1906	2
Miles of stone road contracted for 1906	5
First improved roads built	1895
Proportion of improved roads built since 1895 (per cent.)	88
Satisfaction of farmers with investment in improved roads—	"The majority are well satisfied"
Authority	Jno. C. Prow, Civil Engineer

*Including eight miles of the old New Albany and Vincennes turnpike owned by private corporation and operated as a toll road.

**Not including cost of eight miles of toll road.

Washington County lies near the center of the southern third of the State. It is separated from Lawrence and Jackson Counties on the north by the East Fork of White River, and its largest tributary, the Muscatatuck River. On the east it is bounded by Scott and Clark, on the south by Floyd, Harrison and Crawford, and on the west by Orange and Lawrence counties. The county is one of the larger ones of the State, being 25 miles in extreme width from north to south and 25 miles in greatest length from east to west.

The rocks of four geological epochs of the Lower Carboniferous

Period form its surface. These are the Knobstone, covering the greater part of the northern fourth and eastern third of the county; the Harrodsburg limestone, occurring on the higher hills and ridges east and north of the center; the Bedford Oölitic limestone, occupying narrow, tortuous areas in the central third and northwestern fourth, and the Mitchell limestone, covering the greater part of the western third. A few outliers of the Huron Group also occur in the southwestern portion.

From the vicinity of Salem westward to the county line, especially along the line of the Monon Railway, the surface of the county is generally level, or nearly so. This area comprises the better agricultural portion. The northern and eastern parts of the county are broken and rough. Going westward or southward from the Muscatatuck River, the upper part of the Knobstone is approached. This has a large proportion of sandstone and is capped by the hard limestones of the Harrodsburg Epoch. These withstand erosion much better than the lower members of the Knobstone, and give rise to a belt of country of extremely broken character. The hard, overlying limestones tend to form a high plateau sloping to the west with the dip of the rocks. The eastward and northward flowing streams have eaten through this overlying crust, where it is thinning out along its edge, and once through that and the hard sandstone in the upper part of the Knobstone formation, they have cut rapidly through the soft underlying shales nearly to the base level of the region to the east. The result is a series of valleys from 250 to 300 feet deep and from one to five miles long, separated by narrow divides. The divides tend to be flat-topped, evidently being uneroded prolongations of the plateau. As they extend out from the plateau they tend to become narrower and to have low saddles cut in the crest, and finally the ridge ends abruptly, making a bold headland, to which the name "knob" has been given. The central and southern parts of the county are in many localities considerably broken, but the land is not so rough as much of the north and east.

The creeks of the northern part of the county flow a northerly course, with a slight trend to the west, and empty their waters into the East Fork of White River or the Muscatatuck. Named in order from the west, they are Clifty, Twin, Rush, Buffalo, Delaney

and Elk creeks. All of the eastern and southern portions of the county are drained by Blue River or some of its many branches, its principal tributaries in the county being the North, Middle and South Forks. These unite near Fredericksburg, close to the south county line.

The transportation facilities of the county are poor, the C., I. & L. (Monon) being the only railway within its bounds. This crosses the county in a northwest-southeast direction, passing through Salem, the county seat.

Road Materials.

Washington County is rich in materials suitable for the permanent improvement of her roads, but it is only within the past few years that her citizens have been awakened to the value of good roads, and have begun to utilize the materials which nature has so bounteously bestowed upon them.

Harrodsburg Limestone.—As already noted, this limestone forms the country rock of extensive areas north and east of Salem, the county seat. The portions of townships embracing these areas are the southwestern corner of Gibson, the greater part of Franklin, the northwestern corner of Polk, the eastern third of Jackson and Pierce and the eastern half of Washington. There are also numerous exposures in the ravines and on the slopes of the ridges in western Monroe, central Jefferson and northern Brown.

For the most part, the Harrodsburg Group consists of a series of limestones, with thin beds of shale, and with sandy limestones in place just at the bottom, where it meets the Knobstone. In places the top layers are full of bryozoa. Geodes are usually very abundant in the lower strata and range from two feet in diameter down to a pea in size. The thickness of the series runs from 35 to 90 feet, averaging about 65 in the county. The following section of the face of the quarry below the cemetery just west of Salem, as given by Dr. Ashley,* may be taken as fairly representing the stratigraphy of the Harrodsburg in the county. This quarry has been extensively worked for railway ballast.

*27th Ann. Rep. Ind. Dept. Geol. and Nat. Res., 1902, p. 86.

Section of quarry just west of Salem.

		Feet.	Inches.
1.	Soil, red	2 to 3	..
2.	Bedford oölitic limestone	5	..
	Harrodsburg.		
3.	Light drab limestone, with crow-feet	5	..
4.	Yellow to light drab limestone, with crow-feet	6	..
5.	Light to dark blue limestone, crow-feet, fossiliferous, bryozoa common, top layer crinoidal, numerous cavities with calcite crystals	6	..
6.	Gray, fine-grained limestone, composed largely of finely comminuted crinoid stems and shell fragments	6	..
7.	Soft, blue shale	..	0-6
8.	Gray to drab limestone, similar to No. 6	3	..
9.	Shale like No. 7, only more persistent	..	6
10.	Limestone, like Nos. 6 and 8	4	..
11.	Blue shale	1 to	6
12.	Blue, shaly limestone, full of goedes	2	0+

The upper layers, Nos. 3, 4 and 5, are quite hard and well suited for macadam stone.* Small quarries have been opened in the Harrodsburg stone at many points over the area of its outcrop for securing material for building or repairing the roads.

Mitchell Limestone.—This well known stone comprises the country rock over the greater part of the western half of Washington County and offers an abundance of the best of road material. The townships, or portions thereof, which the Mitchell stone covers are, roughly speaking, as follows: The south half of Brown, the southern third of Jefferson, the western half of Washington, all of Vernon, Madison, Howard and Posey; the western half of Pierce and the western half and southeastern fourth of Jackson. Wherever the streams have eroded their way down through the overlying soil or surface of this area, exposures of the Mitchell stone appear. The general character of this stone and its fitness for road-making have been fully discussed on previous pages.† Suffice it to say that no better macadam material occurs in Indiana than it offers, and the greater proportion of the mileage of improved roads in the county have been built of it.

Of the 20 miles so built in 1905, the Orleans road, running northwest from Salem, had just been completed at the time of my visit. The quarry from which most of the stone was obtained

*For results of tests of Harrodsburg limestone for road purposes see pp. 140, 159.
†See pp. 142, 159.

is located on a branch of Highland Creek, a short distance west of the Monon Railway and about two miles northwest of Salem, northwest quarter of section 13 (2 N., 3 E.). Here the following section was exposed:

Section of quarry two miles northwest of Salem.

		Feet.	Inches.
1.	Soil	2	..
2.	Soft, blue to gray shale	2	6
3.	Hard, light blue to gray Mitchell limestone	12	..
4.	Softer, dark colored limestone	5	..
5.	Oölitic stone	5	..

The upper stone, No. 3, is well suited for macadam, but the next lower layer, No. 4, is too soft and contains too high a percentage of iron oxide for road purposes. The bottom layer, No. 5, should also be condemned on account of its softness. Too high a percentage of these layers had been used in places on the road and as a result water was standing in a number of places in the wheelways. If less than 10 per cent. of these two layers be mixed intimately with the harder material—No. 3—they will cement readily and make a lasting roadway.

One mile to the northeast, on the Bayne land, northwest quarter of section 7 (2 N., 4 E.), is another quarry opened in an outcrop of the Mitchell stone, from which much of the material for the Cox's Ferry and Highland road has been obtained. The stone used is in two layers, a light gray, softer upper course six feet thick and a darker blue, hard, fine-grained stone, 12 feet thick. These had been mixed in the proportion in which they occur and made a good roadway.

A new quarry in the Mitchell stone was just being opened on the land of Charles Cauble, northwest quarter of section 6 (2 N., 4 E.), where the material for the Sparks Ferry road is to be obtained. The exposure on the hillside showed a hard gray stone, which will doubtless serve well as macadam. If care be taken to reject all layers which have a clayey, shale-like appearance, or which approach the oölitic in softness and structure, the Mitchell stone can be depended upon to furnish the best of material for macadam.

Gravel.—The creek gravels of northeastern Washington County have been used on a number of the roads and have proven durable

and excellent in cementing qualities. The gravels from the Harrodsburg limestone areas, composed as they are largely of small, very hard geodes and pieces of flint, make a smooth, firm roadway. The Canton-Salem and the Seaba roads furnish examples where this gravel has been used in working out the taxes. They run through one of the finest farming districts of the county and are in good condition for the greater part of the year. Many of the small geodes are seen along the roadside wherever the Harrodsburg stone forms the surface, and each season the bars on all the streams in this area are replenished, furnishing a never-failing supply of the best of gravels for road improvement.

In Gibson and the greater part of Monroe, Franklin and Polk townships the creek gravel from the decomposing iron carbonate or siderite nodules of the Knobstone furnishes a source of excellent road material which has been utilized to some extent.* On the Little York and Salem road, 11 feet wide, 1,800 cubic yards were used to the mile. This road is six years old and has required very little repairing. The same can be said of the Lesterville and Little York road. This gravel occurs abundantly on Elk Creek and its tributary, Price's Mill Branch, especially in those parts of their courses which run through the knobs or hills. When first used for road construction it sold at 3 cents per yard, but the farmers now ask 5 cents.

A new road two and an eighth miles long, to be built in 1906, will extend from the south edge of section 35 (4 N., 5 E.), north to Tatlock's ferry across the Muscatatuck River. The gravel will be gotten from Robinson's branch to the west of section 32, as the lower course of Elk Creek is through a flat area where there is but little gravel. The engineer's estimate of the cost of the road is $1,600 per mile.

The tributaries of the Middle and Mutton forks of Blue River in Franklin and Polk townships have cut through the overlying Harrodsburg limestone, deep into the Knobstone and large quantities of creek gravel occur on the bars, which is derived from both formations, and is therefore excellent in quality.

The river gravel of the Muscatatuck has been used to some extent on the roads of Washington and Jackson counties, but is

*See p. 128 for an account of the character and quality of this Knobstone gravel.

inferior to that of the creeks, as it is, in general, too fine, and does not pack well.

On the crest of a high hill or knob in section 30 (4 N., 4 E.), Monroe Township, 300 or more feet above the Muscatatuck River, is a deposit of gravel covering about 30 acres which has been used extensively for top dressing the roads of the township, especially the Millport and Salem road, which passes close by the pit. The gravel is composed mostly of chocolate colored chert, pieces of quartzite, and brown and yellow hard sandstone. In size the pebbles range from 3 inches down. There is much oxide of iron intermingled which causes the gravel to cement very closely and firmly, thus making a road surface which does not wear into ruts and which is free from dust at all seasons. The pit has been opened to a depth of 30 feet and the deposit is known to be 20 feet deeper. The gravel sells at 5 cents per cubic yard and is esteemed so highly as a surfacing material that it is hauled several miles across the Muscatatuck River into Jackson County.

Improved Roads.

While the mileage of improved roads in Washington County is not large, those which have been built are, for the most part, well constructed. With such a beginning there is little doubt but that those of the future will be even better.

The first macadamized road in the county was the old New Albany and Vincennes turnpike, built between 1836 and 1839 by the State.* It enters the county near the southeastern corner of Posey Township, southwest quarter of section 14 (1 S., 3 E.), and passing through Fredericksburg and Hardinsburg in a northwesterly direction, enters Orange County from the southwestern corner of Madison Township, southwest quarter of section 33 (1 N., 2 E.). There is, therefore, a little more than 8 miles within Washington County. This is owned by a corporation known as the New Albany and Vincennes Plank Road Co., and is operated as a toll road. Prof. W. W. Borden informs me that there is a stretch of about ½ mile of this road in Floyd County which, as an experiment, was improved with the Knobstone creek gravel instead of stone. The gravel was placed on

*See p. 32 of this report.

the road 18 inches thick for its full width; and, though heavily traveled for nearly 70 years with little repair, it is still a good piece of roadway.

Between 1837 and 1839, the New Albany and Salem pike was also graded as far as Salem and, in part, bridged by the State.* The grade was afterward turned over to the New Albany and Salem Railway, now the main line of the C., I. & L. (Monon), which utilized it to within 12 miles of Salem as a part of their roadbed. This 12 miles was kept up by the county and was finally improved under the free gravel road law.

The Millport and Salem road, extending from Salem northward a distance of 13 miles through Washington and Monroe townships to Millport on the Muscatatuck River, was the first free pike road in the county. At one time it was a plank road, built and operated by W. C. DePauw, who had extensive lumber interests at Millport. It was improved with stone in 1895 and '96, the bottom layer, 5 inches in thickness, being napped on the road to a 5-inch size. On the middle portion this was covered with creek gravel and on the northern end with gravel from the pit near Millport to a depth of 3 inches. On the south end the top dressing was of limestone less than 2 inches in size. As the improved portion is 15 feet wide, teams can easily pass and wagons travel over all parts of the roadway, so that the surface is kept even, there being no wheelway ruts, as on a narrow road, where the wheels travel all the time in the same track. On account of the large sized stone used in the bottom layer, which often, especially on the slopes, work to the surface, the road is quite rough in places, but nowhere becomes muddy or much cut into gullies.

In Gibson Township, in the northeastern corner of the county, there are 7½ miles of road improved with Knobstone gravel from Elk Creek and its tributaries. This cost from $800 to $1,400 per mile, depending upon the distance from the gravel supply. The roads average 11 feet in width, the gravel being placed 12 inches thick in the center and 8 inches on the sides. These roads were constructed for a low price but are smooth and seemingly durable under the traffic to which they are subjected.

In Monroe Township the Millport road, already mentioned, is the only one improved. In Jefferson Township, the Rush Creek

*See p. 30 of this report.

Valley and Sparks Ferry roads are improved with Mitchell limestone. On the Rush Creek road the large bottom stone has worked to the surface in many places and on a portion, seen by the writer during a heavy rainfall, water was running down the gullies of the trackways on all the slopes, showing that the side ditches were not performing their duty. Five miles of the Sparks Ferry road were built by Shrum and Standish, the leading contractors in the county, at a cost of $2,700 per mile. The improved portion is 12 feet in width; the bottom layer, 5 inches thick, being napped to 5-inch ring size, while the upper portion is of crushed stone 2 inches and less in size and placed in 2 layers.

In Brown Township there are several short roads improved with Mitchell stone, and 1 or 2 about Saltillo and Campbellsburgh with creek gravel, of the same quality as used in northeastern Orange County. Vernon Township has no improved roads.

In Washington Township all the main roads leading from Salem, with the exception of the Center road, are improved with stone or with stone base and creek gravel top dressing. The Corydon road begins 1 mile south of Salem and runs to the township line 3 miles. The improved portion is 14 feet in width, built in the same manner as the Millport road, and cost $8,100 for the 3 miles. The Charleston road, 5 miles in length, leaving Salem from the east, was built in 1897 of Harrodsburg limestone, top dressed with creek gravel. It cost $9,000, and is in excellent condition.

The Salem and Livonia road, 12 miles in length, half of which is in Madison Township, is 12 feet in width, of crushed Mitchell stone, 12 inches deep at the center and 6 inches on the side, and cost $2,000 per mile. A 12-foot road is of little, if any, more value than one 10 feet wide. A roadway should be 16 feet wide to allow wagons to pass readily, though they can pass on a 14-foot road by crowding the edges. The main highways subject to heavy traffic should, if possible, be built 14 to 16 feet in width, while for country roads 9 to 10 feet is sufficient.

There are no improved county roads whatever in Franklin, Polk, Pierce and Jackson townships, though many of the country roads in Pierce Township and about Pekin have been improved with Knobstone gravel by the farmers working out their road tax.

In Howard Township there is only 1½ miles of stone road.

This is a part of the Salem and Beck's Mill road, built of Mitchell stone. This road is subjected to heavy travel and has cost more for repairs than any road in the county, mainly on account of the grade being too flat with insufficient drainage on the sides. In Posey Township the old toll road previously mentioned is the only one improved.

A combination of Mitchell limestone and creek gravel makes an excellent road, the gravel being used as a top dressing. The Martinsburg road, 4 miles in length and 10 feet wide, was so constructed in 1897 for $1,500 per mile, and has cost less for repairs than any road in the county. It has a high grade and well constructed side ditches, which have added much to its durability.

STONE CRUSHING PLANTS.

The only stone crushing outfit seen by the writer in the county is that of Shrum & Standish. It was used in producing macadam for 12 or more miles of road in 1905. This outfit consists of the following:

1 No. 4 Austin crusher, costing, with elevator and screen	$1,500
1 Avery 20 H. P. traction engine	1,380
1 Ingersoll steam drill	325

In addition they have a smaller traction engine with which they plow and grade; also a 4-ton steam roller with which they compact the grade and layers of stone on all roads built. When in operation they employ 20 to 25 men and produce about 250 cubic yards of stone daily.

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There are no improved [illegible] Polk, Pierce and Jackson [illegible] roads in Pierce Townshi[illegible] with Knobstone gravel [illegible]

In Howard Town[illegible]

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FIG. 33B. ILLUSTRATING THE DISTRIBUTION OF ROAD MATERIALS IN MONROE COUNTY.

SECTION XIII.

THE ROADS AND ROAD MATERIALS OF MONROE COUNTY.

BY CHARLES W. SHANNON, BLOOMINGTON, INDIANA.

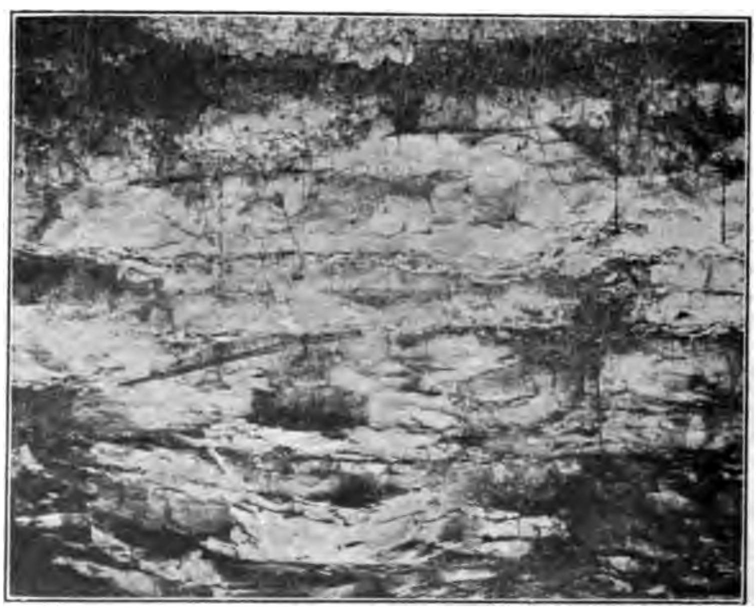
Area in square miles	414
Population in 1900	20,873
Miles of public roads	865
Miles of improved roads	165
Percentage of roads improved	19.1
Miles improved with gravel	None
Miles improved with crushed stone	165
Average original cost of stone roads per mile	$2,200
Total original cost of improved roads	$365,000
Annual cost of repairs per mile on stone roads 5 years old	$60
Miles of improved road (stone) built in 1905	4½
Miles of improved road (stone) contracted for 1906	9
First improved roads built	1880
Proportion of improved roads built since 1895 (per cent.)	80
Satisfaction of farmers with investment in improved roads	Good
Authority	J. M. Kerr, County Auditor

History.—Monroe County, named in honor of James Monroe, fifth President of the United States, was organized in 1818, There are 12 civil townships, with a total area of 414 square miles. The county was first settled in 1819. For many years afterward there were but few roads in the county. The first road was the old State road, but as the land was cleared for farming purposes, the original route of the road was changed in many places, and the old roadbed can be traced through farms in the central and northern parts of the county; other portions of the old road now well improved constitute several miles of the most traveled way in the county.

In these early days there were no other roads except the paths laid out by the settlers as they established their homes in the different parts of the county and found it necessary to open lines of communication with other settlements over the county, and the construction and repair of such roads was a matter of private con-

Plate XVII.

Road-metal quarry in Harrodsburg limestone, one and a half miles north of Bloomington, on North Pike.



(a) Near view of same quarry, showing structure and bedding of the stone.

cern; but many of these ways, however, determined many of the public highways of the present time.

As stated above, there are in the county 865 miles of roadway, with 165 miles improved with crushed stone and gravel. The first improved road in the county was built in 1880 on the Bloomington and Columbus road, east of the city of Bloomington.

Concerning the actual state of the highways of the county for several years but little information is to be found, since in the county offices there is no detailed record of road affairs.

Topography and Its Relations to the Highways.—"All landways are, as regards their location, construction, and maintenance, very greatly affected by geological conditions—by the state of the earth over which the roads pass, by the character of the soil or the underlying rock, by the way in which the materials are affected by rain and frost and the pressure of wheels and the feet of animals, and by the topography of the country."

The diversified physical features of Monroe County have so far reaching an influence upon the many problems presented in highway construction as to demand the careful consideration of the people of the county. The greatest differences in elevation in the county range from 150 to 250 feet. The topography has profoundly influenced the location of the highways. Far too little advantage has, however, been taken of these topographic features in the location of the ordinary roads; notwithstanding this fact, a system of public roads, more or less fully adjusted to the surface of the county, is being gradually built up. One has only to examine the roads to see how frequently advantageous locations have been ignored and very poor positions selected to be convinced of the value of such a system. Many of the roads were built directly across parts of the county without much reference to the topography, with the result that they have a constant succession of ascents and descents; such is especially true where an attempt has been made to have the roads follow the section lines. In general, however, the highways run up and down the valleys, crossing from one to the other at the lowest points in the divides, or following the channel of some stream, which has been able to maintain its course through the ridges. In other cases the roads follow along on the summit of the ridges, and in order that passage may be made from the roads of the valley to those of the

ute. The stone is then dynamited down and loaded into tram-cars, which are elevated by steam power to the level of the larger crusher. From this the broken stone is elevated and passes through a 12-foot rotary screen with ½, 1½ and 2½-inch openings. What does not pass through these openings is returned and passes through the smaller crusher. About 60 men are employed in the quarry and at the plant, the average wage for common labor being $1.40 per day.

The macadam is dumped from bins into cars and sells at 50 cents per ton at the plant, a cubic yard, after screening, weighing about 2,400 pounds. Large quantities of the stone are also ground into a fine powder for glass making and fertilizer purposes. For the latter use it is shipped mainly to Illinois, where it serves to correct the acidity of the soil. This ground stone brings $1.50 per ton at the plant.

In addition to the plants mentioned, the Lehigh Portland Cement Company operates three Gates crushers at their quarry, a half mile north of that of the Mitchell Lime Company. These are Nos. 9, 7½ and 2, respectively. The Mitchell stone is crushed at this quarry only for use in Portland cement manufacture.

ORANGE COUNTY.

Area in square miles	400
Population in 1900	16,854
Miles of public roads	700
Miles of improved roads	168
Percentage of roads improved	24
Miles improved with gravel	40
Miles improved with crushed stone	128
Average original cost of gravel roads per mile	$1,250
Average original cost of stone roads per mile	$1,800
Total original cost of improved roads	$280,000
Annual cost of repairs per mile on gravel roads 5 years old	$30
Annual cost of repairs per mile on stone roads 5 years old	$50
Miles of gravel road built in 1905	1
Miles of stone road built in 1905	30
Miles of gravel road contracted for 1906	3
Miles of stone road contracted for 1906	21
First improved roads built	1897
Satisfaction of farmers with investment in improved roads—	"More than pleased"
Authority	Alvin B. Ham, County Auditor

Authority ....Alvin B. Ham, County Auditor

Orange County occupies a place in the second tier of counties north of the Ohio, about 85 miles southwest of Indianapolis. Lawrence County forms its northern and Crawford its southern boundary. Washington and Crawford bound it on the east and Martin and Dubois on the west. The county is square in outline, being 20 miles in length by 20 in breadth.

The Mitchell limestone forms the surface of the eastern two-thirds of the northern half. The Huron limestones and sandstones cover the southern third and part of the northwestern fourth, while the Mansfield sandstone occurs on the higher ridges in the southwestern and northwestern portions.

The northeastern part of the county, embraced in the Mitchell limestone area, is comparatively level, but the topography is varied by the numerous sink holes and basins characteristic of that formation. The southern, central and especially the western parts of the county are very rugged and broken. High and steep ridges, with narrow winding valleys, are the prevailing surface features. Mount Arie, near West Baden, and Burtin Hill, southwest of French Lick, are two of the highest points in this region. Two streams, Lost River and Patoka River, with their tributaries, drain the county. Their general course is from east to west, but very meandering, the former across the northern and the latter across the southern thirds.

Road Materials.

The northern half of Orange County is abundantly supplied with material suitable for building the best of improved roads, and the great majority of the mileage of such roads is in that portion of the county. In the southern half the roal material is, in most localities, limited to the Huron limestone, though in Southeast township there are numerous exposures of the Mitchell stone.

Mitchell Limestone.—This well known macadam material forms the country rock in Northeast, Orleans, Orangeville and the greater part of Paoli and Stamper's Creek townships. On the higher hills and ridges of the last two townships it is capped with Huron sandstone. The Mitchell stone is easily available almost everywhere in the three first mentioned, lying close to the surface and being exposed in many ravines and the bluffs of all streams.

The Mitchell stone is here, as elsewhere, a compact, even-bedded, gray to blue, fine-grained, calcium carbonate, breaking usually with a conchoidal fracture. The upper three to seven feet usually contains numerous chert nodules, which by decay and erosion of the limestone are often left as component parts of the red clayey soil or surface covering. In thickness the entire formation ranges between 50 and 90 feet.

Numerous abandoned quarries of Mitchell stone occur along the improved stone roads where the metal for their surfacing has been obtained. In October, 1905, but three quarries were being worked in the Mitchell stone for macadam material. Of these, two were visited. The first was by the roadside at the east end of the new steel bridge on the Monon Railway, one-half mile northeast of Paoli. Here a quarry had been recently opened in an exposure of the Mitchell stone to secure material for repairing the Paoli and Orleans macadam road. The face of the quarry was but ten feet in height, with but eight inches to a foot of necessary stripping above. The stone was in nine layers, ranging in thickness from two inches to one foot, and was easily quarried and broken. A force of ten men were at work getting out and crushing the stone. About 50 cubic yards daily were produced on an Indiana road machine operated by a traction engine. Thousands of cubic yards of macadam can be readily obtained at this point, and others in the near vicinity.

The second quarry visited was in the northeast quarter of section 27 (3 N., 1 W.), about two and a half miles northwest of Orleans. Here in the side of a large sink hole a quarry had been recently been opened to secure macadam for building two miles of stone road, running north and south past the quarry. The Mitchell stone was exposed to a depth of 12 feet, with but 6 or 8 inches of stripping above. The stone was much whiter and a little softer than other exposures of the Mitchell stone noted, but otherwise appeared well suited for road construction. The contractor, Mr. O. P. Turley, was receiving $1.00 per cubic yard, or $1,462 per mile, for crushing and placing the stone on the road. He paid $50 to the owner of the land for the stone, with the privilege of hauling over the land about 100 yards to the road. He had just completed a contract of three miles on the same terms—i. e., $1.00 per yard for getting out and hauling the stone, he paying $25 per

mile for the stone privilege from the land owner. For hauling he was paying $2.50 per day for teams, and was working 15 to 35 men in the quarry and at crusher, at an average wage of $1.50. He stated that the Mitchell stone varies much in toughness and difficulty of working. At the quarry just opened he had used but 75 pounds of dynamite in securing enough stone for half a mile of road. At the former quarry worked, about two and a half miles south, he used 1,000 pounds in securing stone for the three miles.

Lying as it does so close to the surface, the Mitchell stone offers throughout most of its area in Orange County an easily available and durable road material; and every road within the area should be improved in the near future.

Samples were taken from the quarry northwest of Orleans and tested in the U. S. Road Laboratory at Washington, the tests resulting as follows:

*Results of Tests of Mitchell Limestone from quarry two and a half miles northwest of Orleans.**

Specific gravity	2.5	French coefficient of wear	9.1
Weight per cu. ft. (lbs.)	155.9	Hardness	8
Water absorbed per cu. ft. (lbs.)	3	Toughness	5
Per cent. of wear	4.4	Cementing value—Dry	11
		Wet	37

"A hard and fairly tough limestone, with average resistance to wear, and fairly good cementing value. Best suited for light highway and country-road traffic."—Page.

An analysis of the same stone showed its chemical composition to be as follows:

Analysis of Mitchell Limestone from quarry two and a half miles northwest of Orleans.

	Per cent.
Alumina (Al_2O_3)	.75
Iron oxide (Fe_2O_3)	Trace
Lime (CaO)	56.00
Magnesia (MgO)	Trace
Insoluble in hydrochloric acid	.40
Loss on ignition	43.23
Total	100.38

*For standard of comparison see p. 79.

Huron Limestones.—The Huron limestones offer an abundance of material for road construction in western and southern Orange County. Their general character and fitness for such purpose has already been mentioned.* One or more of the three Huron limestones are exposed in almost every ravine or creek bluff in Northwest, French Lick, Jackson, Greenfield and Southeast townships, and in the south halves of Paoli and Stamper's Creek, and the west half of Orangeville townships.

The only worked quarry visited was on the farm of Lee Henson, one and a fourth miles east of French Lick, where macadam stone was being secured for improving three and a half miles of the French Lick and Paoli road. At the quarry, which was near the crest of a ridge in the northeast quarter of section 2 (1 N., 2 W.), the hard, blue, semi-crystalline middle Huron stone was opened to a thickness of 14 feet. It was in seven layers, ranging from 9 inches to 6 feet in thickness, with a surface stripping of one to two and a half feet. This stripping was mostly soil and clay, though remains of a thin layer of sandstone occurred in places. The limestone was readily quarried, breaking freely with a hammer. The land owner was paid $25 per mile of road for the stone used. A National jaw-crusher, with eight-foot revolving screen and Ingersoll steam drill, were used.

Where the Huron stone is broken to the proper fineness, it seems to pack well, though no steam roller was being used on the roads in course of construction. The contractors—Smith Bros. of French Lick—had just completed three and a half miles to the south of that town, in which the same limestone was used.

Gravel.—In the northeastern part of Orange County, notably along Lost River and its tributaries in Orleans and Northeast townships, occurs a creek gravel which has been used extensively in road building. It is composed largely of chert nodules from the upper portion of the Mitchell stone, and small geodes from the Harrodsburg limestone to the east, combined with enough red clay and particles of iron carbonate to cause it to pack firmly and make a road surface equal in smoothness and durability to that of any gravel road which has come to the writer's notice in the State. A sample of this gravel was secured from a bar of Lost River on

*See p. 143 of this report.

the land of Cyrus Finley, just above the Finley ford, three and a half miles southeast of Orleans, and tested at Washington, the results of the test showing its dry grinding cementing value to be 19, as against 82 for the average of 59 samples of gravel previously tested at the laboratory, and its grinding value 58. Of it Mr. Page wrote as follows: "A gravel with good cementing value; will do well for gravel roads or as a binder." About 40 miles of roads have been improved from the bars of Lost River and new bars are constantly forming each year. The stream gravel in the southern part of the county, as well as that about French Lick, in the northwestern portion, is of no value for roads, as it is largely composed of fragments of the Huron and Mansfield sandstones, which quickly grind into dust.

Improved Roads.

The majority of the 168 miles of improved roads of Orange County have been well constructed of good material, and are proving an investment with which the farmers are "more than pleased." The first improved road in the county was the old New Albany and Paoli turnpike, finished by the State in 1839,* and later turned over to a private corporation, which operated it as a toll road until 1897, when the eleven miles of it in Orange County were purchased for $1,000 per mile and made free. It was macadamized mostly with Mitchell limestone secured from alongside its course and napped by hand on the road. The first free improved road constructed under the present law was the Orleans and Paoli pike, built in 1897 on the same plan, the road metal being placed in three layers and all broken by hand. The first layer, four inches thick, was composed of stone four or five inches in size. The second layer, three inches thick, was of stone three inches in size, and the top layer, three inches thick, of finer stone. The road was ten feet wide, and on level ground is yet in good condition, but the drainage on the inclines was not sufficient, the ditches being too shallow, and in such places the road has been badly washed each year. A heavy rainfall in September, 1905, in many places washed great gullies through the center of the road and exposed in others the large stone at the bottom. The citi-

*See p. 33 of this report.

zens profited by experience, and all stone roads are now being built with better grades, better drainage and with stone crushed by machinery.. The grades are built 14 to 16 feet in width, with the macadam 10 feet wide and well embanked on each side.

When the first elections for improved roads were held in the county there was strong opposition, the farmers having exaggerated ideas of their cost, and the elections were carried by a bare majority. Now from 65 to 85 per cent. of the total vote is cast in favor of road improvement.

In Southeast Township there is not yet a mile of improved road, but a contract has been let for improving the Paoli and Leavenworth road with stone in 1906. North of Valeen the road runs along a narrow ridge and stone can be gotten from the slope on either side.

In Greenfield Township there is not a mile of improved road, and none under consideration, though Huron limestone is abundant. In Jackson Township the contract is let for improving the French Lick and Newton Stewart road with Huron limestone as far as the 4 per cent. levy will permit.

In French Lick Township seven miles were improved with Huron stone in 1905, Smith Bros., the contractors, building three and a half miles of the Unionville road for $1,920 per mile and three and a half miles of the French Lick and Paoli road for $1,980 per mile. Two layers of three-inch stone, each three inches thick, were covered with a top layer, also three inches thick, of one-inch stone. All the principal roads radiating from French Lick and West Baden are now improved with stone.

In Paoli Township there are eleven pike roads constructed of Mitchell stone either leading into Paoli or connecting with one another just outside the town. The Orleans and Paoli road, the first built, is one of the poorest in the county.

In Stamper's Creek Township the road east and west through Millersburg to the Washington County line is of stone, and one other is building south of Millersburg.

The roads of Northeast Township are all of the creek gravel of Lost River and excellent in character. In many instances the gravel was hauled three to five miles over Mitchell stone, but as the stone lies deep, with heavy stripping, the gravel was considered the cheaper.

In Orleans Township most all roads are improved, 40 per cent. with gravel and 60 per cent. with stone. On two or three of the roads the base of the surface is of stone and the top dressing of creek gravel, a combination which seems successful. The Orleans and Livonia all-gravel road is one of the best in the State, the surface very smooth, well packed, a brownish yellow in color, with little dust in dry and no mud in rainy season. Some of these gravel roads, for example the Lancaster and Valeen roads, are six years old and have required little if any repairing. These roads are, however, mostly on level land, and might not prove so smooth and durable were they in the broken region to the west or south. The two miles of stone road built in 1905, west of Orleans, cost $1,700 per mile. Neither the grade or drainage is all that it should be, and no roller was used in compacting the stone. Otherwise it was very well constructed.

In the northern part of Orangeville Township one and three-quarter miles of stone road was being constructed in October at a cost of $1,250 per mile. The stone was all of one size, the surface to be nine inches thick and nine feet wide. The estimate had been placed too low and the contractor threw up his job, it being afterward finished by the residents along the line. Four miles of the Orleans and Orangeville road was built for $1,350 a mile, the basal stone being four inches in size and the top layer one and a half inches.

In Northwest Township the West Baden and Huron road, running north and south across the township, is of crushed stone.

Mr. O. P. Turley, the contractor above mentioned as crushing stone for a road in Orleans Township, has an excellent portable outfit for producing macadam. He kindly gave me the cost of the same as follows:

No. 4 Austin jaw-crusher, including rotary screen and elevator.....	$900
Ingersoll steam drill..	300
16 H. P. Huber traction engine...................................	1,750

The engine runs both crusher and drill. The former has a capacity of 200 yards of macadam daily, but only from 125 to 135 yards were being produced. The screen is eight feet long, with one and a half to two and a half-inch openings, each sized opening being over a separate bin. To the prices above given the freight must be added.

All in all, Orange County is to be congratulated on the excellent beginning she has made in solving the good roads problem. If in the future a little more care be given to grading and drainage and a heavy steam roller be used on each layer of stone or gravel, the roads will be so much the better and more lasting. It is to be hoped that the good work will continue until every road of any importance in the county will be permanently improved.

WASHINGTON COUNTY.

Area in square miles	523
Population in 1900	19,409
Miles of public roads	1,500
Miles of improved roads	113*
Percentage of roads improved	7.5
Miles improved with gravel	8
Miles improved with crushed stone	105
Average original cost of gravel road per mile	$900
Average original cost of stone road per mile	$2,000
Total original cost of improved roads	$183,200**
Annual cost of repairs on gravel roads 5 years old	$50
Annual cost of repairs on stone roads 5 years old	$100
Miles of stone road built in 1905	20
Miles of gravel road contracted for 1906	2
Miles of stone road contracted for 1906	5
First improved roads built	1895
Proportion of improved roads built since 1895 (per cent.)	88
Satisfaction of farmers with investment in improved roads—	"The majority are well satisfied"
Authority	Jno. C. Prow, Civil Engineer

*Including eight miles of the old New Albany and Vincennes turnpike owned by private corporation and operated as a toll road.

**Not including cost of eight miles of toll road.

Washington County lies near the center of the southern third of the State. It is separated from Lawrence and Jackson Counties on the north by the East Fork of White River, and its largest tributary, the Muscatatuck River. On the east it is bounded by Scott and Clark, on the south by Floyd, Harrison and Crawford, and on the west by Orange and Lawrence counties. The county is one of the larger ones of the State, being 25 miles in extreme width from north to south and 25 miles in greatest length from east to west.

The rocks of four geological epochs of the Lower Carboniferous

Period form its surface. These are the Knobstone, covering the greater part of the northern fourth and eastern third of the county; the Harrodsburg limestone, occurring on the higher hills and ridges east and north of the center; the Bedford Oölitic limestone, occupying narrow, tortuous areas in the central third and northwestern fourth, and the Mitchell limestone, covering the greater part of the western third. A few outliers of the Huron Group also occur in the southwestern portion.

From the vicinity of Salem westward to the county line, especially along the line of the Monon Railway, the surface of the county is generally level, or nearly so. This area comprises the better agricultural portion. The northern and eastern parts of the county are broken and rough. Going westward or southward from the Muscatatuck River, the upper part of the Knobstone is approached. This has a large proportion of sandstone and is capped by the hard limestones of the Harrodsburg Epoch. These withstand erosion much better than the lower members of the Knobstone, and give rise to a belt of country of extremely broken character. The hard, overlying limestones tend to form a high plateau sloping to the west with the dip of the rocks. The eastward and northward flowing streams have eaten through this overlying crust, where it is thinning out along its edge, and once through that and the hard sandstone in the upper part of the Knobstone formation, they have cut rapidly through the soft underlying shales nearly to the base level of the region to the east. The result is a series of valleys from 250 to 300 feet deep and from one to five miles long, separated by narrow divides. The divides tend to be flat-topped, evidently being uneroded prolongations of the plateau. As they extend out from the plateau they tend to become narrower and to have low saddles cut in the crest, and finally the ridge ends abruptly, making a bold headland, to which the name "knob" has been given. The central and southern parts of the county are in many localities considerably broken, but the land is not so rough as much of the north and east.

The creeks of the northern part of the county flow a northerly course, with a slight trend to the west, and empty their waters into the East Fork of White River or the Muscatatuck. Named in order from the west, they are Clifty, Twin, Rush, Buffalo, Delaney

and Elk creeks. All of the eastern and southern portions of the county are drained by Blue River or some of its many branches, its principal tributaries in the county being the North, Middle and South Forks. These unite near Fredericksburg, close to the south county line.

The transportation facilities of the county are poor, the C., I. & L. (Monon) being the only railway within its bounds. This crosses the county in a northwest-southeast direction, passing through Salem, the county seat.

Road Materials.

Washington County is rich in materials suitable for the permanent improvement of her roads, but it is only within the past few years that her citizens have been awakened to the value of good roads, and have begun to utilize the materials which nature has so bounteously bestowed upon them.

Harrodsburg Limestone.—As already noted, this limestone forms the country rock of extensive areas north and east of Salem, the county seat. The portions of townships embracing these areas are the southwestern corner of Gibson, the greater part of Franklin, the northwestern corner of Polk, the eastern third of Jackson and Pierce and the eastern half of Washington. There are also numerous exposures in the ravines and on the slopes of the ridges in western Monroe, central Jefferson and northern Brown.

For the most part, the Harrodsburg Group consists of a series of limestones, with thin beds of shale, and with sandy limestones in place just at the bottom, where it meets the Knobstone. In places the top layers are full of bryozoa. Geodes are usually very abundant in the lower strata and range from two feet in diameter down to a pea in size. The thickness of the series runs from 35 to 90 feet, averaging about 65 in the county. The following section of the face of the quarry below the cemetery just west of Salem, as given by Dr. Ashley,* may be taken as fairly representing the stratigraphy of the Harrodsburg in the county. This quarry has been extensively worked for railway ballast.

*27th Ann. Rep. Ind. Dept. Geol. and Nat. Res., 1902, p. 86.

Section of quarry just west of Salem.

		Feet.	Inches.
1.	Soil, red	2 to 3	..
2.	Bedford oölitic limestone	5	..
	Harrodsburg.		
3.	Light drab limestone, with crow-feet	5	..
4.	Yellow to light drab limestone, with crow-feet	6	..
5.	Light to dark blue limestone, crow-feet, fossiliferous, bryozoa common, top layer crinoidal, numerous cavities with calcite crystals	6	..
6.	Gray, fine-grained limestone, composed largely of finely comminuted crinoid stems and shell fragments	6	..
7.	Soft, blue shale	..	0-6
8.	Gray to drab limestone, similar to No. 6	3	..
9.	Shale like No. 7, only more persistent	..	6
10.	Limestone, like Nos. 6 and 8	4	..
11.	Blue shale	1 to	6
12.	Blue, shaly limestone, full of goedes	2	0+

The upper layers, Nos. 3, 4 and 5, are quite hard and well suited for macadam stone.* Small quarries have been opened in the Harrodsburg stone at many points over the area of its outcrop for securing material for building or repairing the roads.

Mitchell Limestone.—This well known stone comprises the country rock over the greater part of the western half of Washington County and offers an abundance of the best of road material. The townships, or portions thereof, which the Mitchell stone covers are, roughly speaking, as follows: The south half of Brown, the southern third of Jefferson, the western half of Washington, all of Vernon, Madison, Howard and Posey; the western half of Pierce and the western half and southeastern fourth of Jackson. Wherever the streams have eroded their way down through the overlying soil or surface of this area, exposures of the Mitchell stone appear. The general character of this stone and its fitness for road-making have been fully discussed on previous pages.† Suffice it to say that no better macadam material occurs in Indiana than it offers, and the greater proportion of the mileage of improved roads in the county have been built of it.

Of the 20 miles so built in 1905, the Orleans road, running northwest from Salem, had just been completed at the time of my visit. The quarry from which most of the stone was obtained

*For results of tests of Harrodsburg limestone for road purposes see pp. 140, 159.
†See pp. 142, 159.

and Elk creeks. All of the eastern and southern portions of the county are drained by Blue River or some of its many branches, its principal tributaries in the county being the North, Middle and South Forks. These unite near Fredericksburg, close to the south county line.

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is located on a branch of Highland Creek, a short distance west of the Monon Railway and about two miles northwest of Salem, northwest quarter of section 13 (2 N., 3 E.). Here the following section was exposed:

Section of quarry two miles northwest of Salem.

		Feet.	Inches.
1.	Soil	2	..
2.	Soft, blue to gray shale	2	6
3.	Hard, light blue to gray Mitchell limestone	12	..
4.	Softer, dark colored limestone	5	..
5.	Oölitic stone	5	..

The upper stone, No. 3, is well suited for macadam, but the next lower layer, No. 4, is too soft and contains too high a percentage of iron oxide for road purposes. The bottom layer, No. 5, should also be condemned on account of its softness. Too high a percentage of these layers had been used in places on the road and as a result water was standing in a number of places in the wheelways. If less than 10 per cent. of these two layers be mixed intimately with the harder material—No. 3—they will cement readily and make a lasting roadway.

One mile to the northeast, on the Bayne land, northwest quarter of section 7 (2 N., 4 E.), is another quarry opened in an outcrop of the Mitchell stone, from which much of the material for the Cox's Ferry and Highland road has been obtained. The stone used is in two layers, a light gray, softer upper course six feet thick and a darker blue, hard, fine-grained stone, 12 feet thick. These had been mixed in the proportion in which they occur and made a good roadway.

A new quarry in the Mitchell stone was just being opened on the land of Charles Cauble, northwest quarter of section 6 (2 N., 4 E.), where the material for the Sparks Ferry road is to be obtained. The exposure on the hillside showed a hard gray stone, which will doubtless serve well as macadam. If care be taken to reject all layers which have a clayey, shale-like appearance, or which approach the oölitic in softness and structure, the Mitchell stone can be depended upon to furnish the best of material for macadam.

Gravel.—The creek gravels of northeastern Washington County have been used on a number of the roads and have proven durable

and excellent in cementing qualities. The gravels from the Harrodsburg limestone areas, composed as they are largely of small, very hard geodes and pieces of flint, make a smooth, firm roadway. The Canton-Salem and the Seaba roads furnish examples where this gravel has been used in working out the taxes. They run through one of the finest farming districts of the county and are in good condition for the greater part of the year. Many of the small geodes are seen along the roadside wherever the Harrodsburg stone forms the surface, and each season the bars on all the streams in this area are replenished, furnishing a never-failing supply of the best of gravels for road improvement.

In Gibson and the greater part of Monroe, Franklin and Polk townships the creek gravel from the decomposing iron carbonate or siderite nodules of the Knobstone furnishes a source of excellent road material which has been utilized to some extent.* On the Little York and Salem road, 11 feet wide, 1,800 cubic yards were used to the mile. This road is six years old and has required very little repairing. The same can be said of the Lesterville and Little York road. This gravel occurs abundantly on Elk Creek and its tributary, Price's Mill Branch, especially in those parts of their courses which run through the knobs or hills. When first used for road construction it sold at 3 cents per yard, but the farmers now ask 5 cents.

A new road two and an eighth miles long, to be built in 1906, will extend from the south edge of section 35 (4 N., 5 E.), north to Tatlock's ferry across the Muscatatuck River. The gravel will be gotten from Robinson's branch to the west of section 32, as the lower course of Elk Creek is through a flat area where there is but little gravel. The engineer's estimate of the cost of the road is $1,600 per mile.

The tributaries of the Middle and Mutton forks of Blue River in Franklin and Polk townships have cut through the overlying Harrodsburg limestone, deep into the Knobstone and large quantities of creek gravel occur on the bars, which is derived from both formations, and is therefore excellent in quality.

The river gravel of the Muscatatuck has been used to some extent on the roads of Washington and Jackson counties, but is

*See p. 128 for an account of the character and quality of this Knobstone gravel.

inferior to that of the creeks, as it is, in general, too fine, and does not pack well.

On the crest of a high hill or knob in section 30 (4 N., 4 E.), Monroe Township, 300 or more feet above the Muscatatuck River, is a deposit of gravel covering about 30 acres which has been used extensively for top dressing the roads of the township, especially the Millport and Salem road, which passes close by the pit. The gravel is composed mostly of chocolate colored chert, pieces of quartzite, and brown and yellow hard sandstone. In size the pebbles range from 3 inches down. There is much oxide of iron intermingled which causes the gravel to cement very closely and firmly, thus making a road surface which does not wear into ruts and which is free from dust at all seasons. The pit has been opened to a depth of 30 feet and the deposit is known to be 20 feet deeper. The gravel sells at 5 cents per cubic yard and is esteemed so highly as a surfacing material that it is hauled several miles across the Muscatatuck River into Jackson County.

Improved Roads.

While the mileage of improved roads in Washington County is not large, those which have been built are, for the most part, well constructed. With such a beginning there is little doubt but that those of the future will be even better.

The first macadamized road in the county was the old New Albany and Vincennes turnpike, built between 1836 and 1839 by the State.* It enters the county near the southeastern corner of Posey Township, southwest quarter of section 14 (1 S., 3 E.), and passing through Fredericksburg and Hardinsburg in a northwesterly direction, enters Orange County from the southwestern corner of Madison Township, southwest quarter of section 33 (1 N., 2 E.). There is, therefore, a little more than 8 miles within Washington County. This is owned by a corporation known as the New Albany and Vincennes Plank Road Co., and is operated as a toll road. Prof. W. W. Borden informs me that there is a stretch of about ½ mile of this road in Floyd County which, as an experiment, was improved with the Knobstone creek gravel instead of stone. The gravel was placed on

*See p. 32 of this report.

the road 18 inches thick for its full width; and, though heavily traveled for nearly 70 years with little repair, it is still a good piece of roadway.

Between 1837 and 1839, the New Albany and Salem pike was also graded as far as Salem and, in part, bridged by the State.* The grade was afterward turned over to the New Albany and Salem Railway, now the main line of the C., I. & L. (Monon), which utilized it to within 12 miles of Salem as a part of their roadbed. This 12 miles was kept up by the county and was finally improved under the free gravel road law.

The Millport and Salem road, extending from Salem northward a distance of 13 miles through Washington and Monroe townships to Millport on the Muscatatuck River, was the first free pike road in the county. At one time it was a plank road, built and operated by W. C. DePauw, who had extensive lumber interests at Millport. It was improved with stone in 1895 and '96, the bottom layer, 5 inches in thickness, being napped on the road to a 5-inch size. On the middle portion this was covered with creek gravel and on the northern end with gravel from the pit near Millport to a depth of 3 inches. On the south end the top dressing was of limestone less than 2 inches in size. As the improved portion is 15 feet wide, teams can easily pass and wagons travel over all parts of the roadway, so that the surface is kept even, there being no wheelway ruts, as on a narrow road, where the wheels travel all the time in the same track. On account of the large sized stone used in the bottom layer, which often, especially on the slopes, work to the surface, the road is quite rough in places, but nowhere becomes muddy or much cut into gullies.

In Gibson Township, in the northeastern corner of the county, there are 7½ miles of road improved with Knobstone gravel from Elk Creek and its tributaries. This cost from $800 to $1,400 per mile, depending upon the distance from the gravel supply. The roads average 11 feet in width, the gravel being placed 12 inches thick in the center and 8 inches on the sides. These roads were constructed for a low price but are smooth and seemingly durable under the traffic to which they are subjected.

In Monroe Township the Millport road, already mentioned, is the only one improved. In Jefferson Township, the Rush Creek

*See p. 30 of this report.

Valley and Sparks Ferry roads are improved with Mitchell limestone. On the Rush Creek road the large bottom stone has worked to the surface in many places and on a portion, seen by the writer during a heavy rainfall, water was running down the gullies of the trackways on all the slopes, showing that the side ditches were not performing their duty. Five miles of the Sparks Ferry road were built by Shrum and Standish, the leading contractors in the county, at a cost of $2,700 per mile. The improved portion is 12 feet in width; the bottom layer, 5 inches thick, being napped to 5-inch ring size, while the upper portion is of crushed stone 2 inches and less in size and placed in 2 layers.

In Brown Township there are several short roads improved with Mitchell stone, and 1 or 2 about Saltillo and Campbellsburgh with creek gravel, of the same quality as used in northeastern Orange County. Vernon Township has no improved roads.

In Washington Township all the main roads leading from Salem, with the exception of the Center road, are improved with stone or with stone base and creek gravel top dressing. The Corydon road begins 1 mile south of Salem and runs to the township line 3 miles. The improved portion is 14 feet in width, built in the same manner as the Millport road, and cost $8,100 for the 3 miles. The Charleston road, 5 miles in length, leaving Salem from the east, was built in 1897 of Harrodsburg limestone, top dressed with creek gravel. It cost $9,000, and is in excellent condition.

The Salem and Livonia road, 12 miles in length, half of which is in Madison Township, is 12 feet in width, of crushed Mitchell stone, 12 inches deep at the center and 6 inches on the side, and cost $2,000 per mile. A 12-foot road is of little, if any, more value than one 10 feet wide. A roadway should be 16 feet wide to allow wagons to pass readily, though they can pass on a 14-foot road by crowding the edges. The main highways subject to heavy traffic should, if possible, be built 14 to 16 feet in width, while for country roads 9 to 10 feet is sufficient.

There are no improved county roads whatever in Franklin, Polk, Pierce and Jackson townships, though many of the country roads in Pierce Township and about Pekin have been improved with Knobstone gravel by the farmers working out their road tax.

In Howard Township there is only $1\frac{1}{2}$ miles of stone road.

This is a part of the Salem and Beck's Mill road, built of Mitchell stone. This road is subjected to heavy travel and has cost more for repairs than any road in the county, mainly on account of the grade being too flat with insufficient drainage on the sides. In Posey Township the old toll road previously mentioned is the only one improved.

A combination of Mitchell limestone and creek gravel makes an excellent road, the gravel being used as a top dressing. The Martinsburg road, 4 miles in length and 10 feet wide, was so constructed in 1897 for $1,500 per mile, and has cost less for repairs than any road in the county. It has a high grade and well constructed side ditches, which have added much to its durability.

Stone Crushing Plants.

The only stone crushing outfit seen by the writer in the county is that of Shrum & Standish. It was used in producing macadam for 12 or more miles of road in 1905. This outfit consists of the following:

1 No. 4 Austin crusher, costing, with elevator and screen...........	$1,500
1 Avery 20 H. P. traction engine..................................	1,380
1 Ingersoll steam drill..	325

In addition they have a smaller traction engine with which they plow and grade; also a 4-ton steam roller with which they compact the grade and layers of stone on all roads built. When in operation they employ 20 to 25 men and produce about 250 cubic yards of stone daily.

FIG. 53B. ILLUSTRATING THE DISTRIBUTION OF ROAD MATERIALS IN MONROE COUNTY

SECTION XIII.

THE ROADS AND ROAD MATERIALS OF MONROE COUNTY.

BY CHARLES W. SHANNON, BLOOMINGTON, INDIANA.

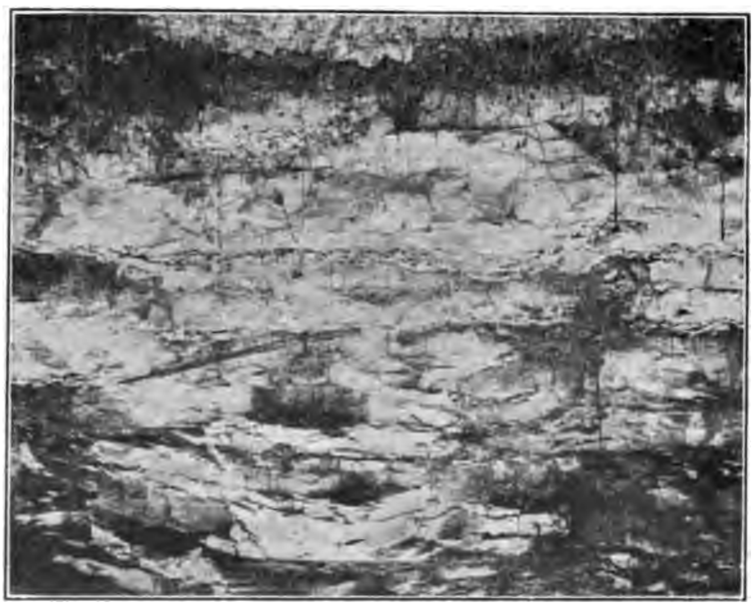
Area in square miles	414
Population in 1900	20,873
Miles of public roads	865
Miles of improved roads	165
Percentage of roads improved	19.1
Miles improved with gravel	None
Miles improved with crushed stone	165
Average original cost of stone roads per mile	$2,200
Total original cost of improved roads	$365,000
Annual cost of repairs per mile on stone roads 5 years old	$60
Miles of improved road (stone) built in 1905	4½
Miles of improved road (stone) contracted for 1906	9
First improved roads built	1880
Proportion of improved roads built since 1895 (per cent.)	80
Satisfaction of farmers with investment in improved roads	Good
Authority	J. M. Kerr, County Auditor

History.—Monroe County, named in honor of James Monroe, fifth President of the United States, was organized in 1818, There are 12 civil townships, with a total area of 414 square miles. The county was first settled in 1819. For many years afterward there were but few roads in the county. The first road was the old State road, but as the land was cleared for farming purposes, the original route of the road was changed in many places, and the old roadbed can be traced through farms in the central and northern parts of the county; other portions of the old road now well improved constitute several miles of the most traveled way in the county.

In these early days there were no other roads except the paths laid out by the settlers as they established their homes in the different parts of the county and found it necessary to open lines of communication with other settlements over the county, and the construction and repair of such roads was a matter of private con-

Plate XVII.

Road-metal quarry in Harrodsburg limestone, one and a half miles north of Bloomington, on North Pike.



(a) Near view of same quarry, showing structure and bedding of the stone.

cern; but many of these ways, however, determined many of the public highways of the present time.

As stated above, there are in the county 865 miles of roadway, with 165 miles improved with crushed stone and gravel. The first improved road in the county was built in 1880 on the Bloomington and Columbus road, east of the city of Bloomington.

Concerning the actual state of the highways of the county for several years but little information is to be found, since in the county offices there is no detailed record of road affairs.

Topography and Its Relations to the Highways.—"All landways are, as regards their location, construction, and maintenance, very greatly affected by geological conditions—by the state of the earth over which the roads pass, by the character of the soil or the underlying rock, by the way in which the materials are affected by rain and frost and the pressure of wheels and the feet of animals, and by the topography of the country."

The diversified physical features of Monroe County have so far reaching an influence upon the many problems presented in highway construction as to demand the careful consideration of the people of the county. The greatest differences in elevation in the county range from 150 to 250 feet. The topography has profoundly influenced the location of the highways. Far too little advantage has, however, been taken of these topographic features in the location of the ordinary roads; notwithstanding this fact, a system of public roads, more or less fully adjusted to the surface of the county, is being gradually built up. One has only to examine the roads to see how frequently advantageous locations have been ignored and very poor positions selected to be convinced of the value of such a system. Many of the roads were built directly across parts of the county without much reference to the topography, with the result that they have a constant succession of ascents and descents; such is especially true where an attempt has been made to have the roads follow the section lines. In general, however, the highways run up and down the valleys, crossing from one to the other at the lowest points in the divides, or following the channel of some stream, which has been able to maintain its course through the ridges. In other cases the roads follow along on the summit of the ridges, and in order that passage may be made from the roads of the valley to those of the

much higher elevations it would appear that steep grades could not be avoided. This adjustment of the highways to the topography of the county, although being carried out with marked intelligence as regards the general conditions involved, presents generally, as described, many errors in detailed location. Frequently a very small amount of grading would make it possible to utilize the natural relief of the land. It is clearly evident that new locations better adjusted to the topography of the county will have to be selected along many portions of the main roads before they can be made of the greatest practical benefit to the agricultural and commercial interests of the county. Such adjustments, whether in the location of new roads or in the relocation and grading of old ones will necessitate the careful and intelligent use of engineering methods. To the surveyor in charge of such work an accurate topographic map of the county would be of inestimable value, as in this way routes could be projected by the surveyor without the expense of a survey, and in this way it would be very easy to compute the relative grades presented by several possible ways.

Grades and Drainage.—The steepest, most rugged and wildest portions of the county are found in parts of Marion, Washington, Indian Creek and Polk townships, where the roadways are so little traveled that the roads are little better than well cleared paths through the woods. The difficulties have also been so great that little effort has been made to locate and construct these roads to advantage. That these difficulties are surmountable is shown in the few roads of the better class that pass through these parts. The Unionville-Martinsville road, which passes through Hubbard's Gap, although unimproved with any road metal, could be made an excellent road with a relatively small amount of grading, and by the use of the stream gravel of that section of the county, which will be described later, the construction could be completed at a very reasonable cost, and would become a much traveled road.

The several miles of road leading through the county and known as the Gosport and Columbus road, is an unimproved road and presents some very difficult problems along a considerable part of its way.

Perhaps the greatest improvement that can be made in a road would be to lessen the grade. Such an improvement will be noted on the new stone road to be built in Indian Creek Township,

Plate XVIII.

View in quarry of Mitchell limestone, on farm of James Blair, northwest of Bloomington.

View in quarry of Mitchell limestone, west of cemetery, Bloomington.

passing through Buena Vista and along Little Indian Creek and over the ridges to the east, in such places as the route is changed from the old way to avoid the steep grades.

In many parts of the county the connection between the valley and ridge part of the road involves steep grades, which invariably are much higher than is suitable for a good highway. Although a grade greater than 5 per cent. is impracticable, grades of 12 to 15 per cent. are of frequent occurrence. Examples of such grades are found at Mt. Tabor; near Stinesville; south of the Reeves Schoolhouse; and west of the Cross Roads church. All the above are in Bean Blossom and Richland townships and are on improved roads. Other such grades are found on the old State road north of Hindostan; on the Gosport and Columbus road, in Washington Township; and near the Precinct Church, and several other places along the eastern part of Marion Township. In Clear Creek Township very steep grades are found on the Harrodsburg Pike, just east of the railway station, and also in section 13, near the township line.

On many of the roads 10 per cent. grades are very common, and in a number of cases where the roads follow the section lines, 6 or 8 such grades occur in 1 mile.

Such steepness in the roads, together with the roughness of their surface, precludes economic hauling. The greatest load which can be hauled over a road is the load which can be hauled through the deepest mud hole or up the steepest hill on that road. The cost of hauling is, therefore, necessarily increased in proportion to the roughness of the surface and the steepness of the grade. We find from Gillespie that "if a horse can pull on a level 1,000 pounds, on a rise of 1 foot in 10 he draws only 250 pounds; that is, on a grade of 10 per cent. he is able to draw only $1/4$ as much as on a level road, and that it costs $1\frac{1}{2}$ times as much to haul over a road having a 5 per cent. grade, and 3 times as much to haul over one having a grade of 10 per cent. as on a level road." As a perfectly level road can seldom be had for any great distance, it is well to know the steepest grade allowable. "If the hill be one of great length, it is best to have the lowest part steepest upon which the horse is capable of exerting his full strength, and to make the slope more gentle toward the summit,

Plate XIX.

Road-metal quarry in the Harrodsburg limestone, two miles southwest of Gosport, near River Bridge.

Trench through deposit of cherty gravel, along Jack's Defeat Creek at Stinesville.

Plate XX.

Side view of stone crusher, showing elevator and box dump for loading the crushed stone in the wagons.

View of quarry and crusher, showing the feeding of stone into the crusher and the means for screening the crushed material.

to correspond with the continually decreasing strength of the fatigued animal."

An essential feature of a good road is good drainage, and the principles of good drainage remain practically the same whether the road be constructed of earth, gravel or stone. There are many places in the county where washouts in the roads are of very common occurrence. It is safe to say that if the steep grades were properly reduced, 1-3 of the roads now frequently rendered almost impassable from washouts would be free from the effects of such accidents. "The wear to a roadbed increases with the velocity of the storm water flowing down it, and the velocity depends primarily upon the grade." Aside from the grade the first demand of good drainage is to attend to the shape of the road surface. On most of the improved roads of the county the surface has been crowned, or rounded up in the center, so that there is a fall from the center to the sides, thus compelling the water to flow rapidly from the surface into the gutters and ditches on the sides of the roads. On some of the first improved roads the surface has become almost flat and even in some cases depressed, so that the water is not shed from the surface, but is absorbed by the material of the road. The material then loses its firmness and yields to the grinding action of the wheels of vehicles. The surface thus becomes rutted and if not properly attended to at once is almost destroyed. When the water is allowed to stand in the holes in the roads, especially the earth roads, the ruts become deeper and deeper, until the road becomes quite impassable, as is frequently found in many parts of the county during the winter and spring seasons. The earth roads in these parts of the county where the soil is the stiff, red, residual clay of the Harrodsburg Limestone, become very bad even after a summer shower. In the Mitchell Limestone and the Knobstone regions the roads become dry very much quicker, and in this particular do not present as great a difficulty as to the drainage.

The effect of locked wheels upon the surface of the road is readily seen on the hillsides of the earth roads and in many places on the improved stone roads. The locked wheels of the heavily loaded wagons cut down through the surface and trenches are formed down the slope of the hill. Every wheel track on an

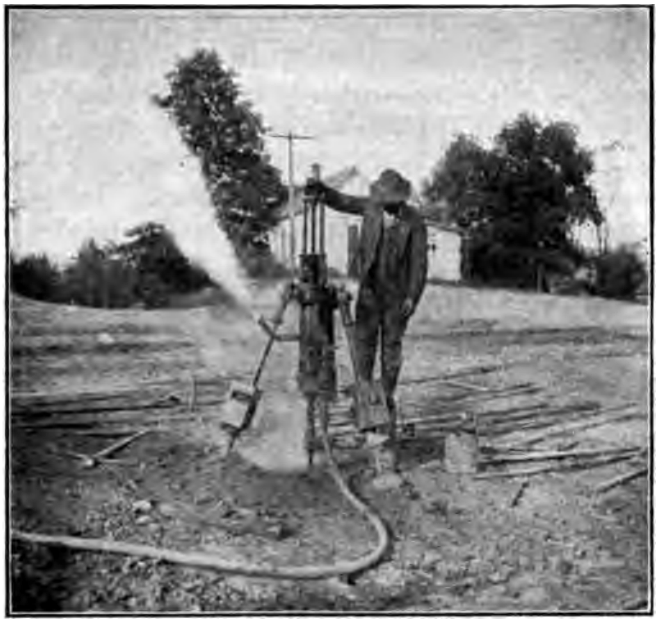
inclined roadway becomes a channel for carrying down the water, and unless some means of turning the water off to the sides is provided for, these tracks are quickly deepened into waterways and will destroy the best improved roads; not only that, but such trenches become sources of danger to vehicles passing over such roads.

Upon the steeper portions of many of the roads "water-breaks" or "breakers" have been constructed at intervals of a few feet, for the purpose of turning to one side the storm-water, and thus prevent the gullying of the roadway. These breakers are made in various ways; usually they consist of a mound of earth or stone extending directly across the roadway. Although these serve very well their purpose of turning the water to the side, they form bad obstructions to travel and increase the work of a horse hauling over them. In a few cases in the northeastern part of the county these breakers consist of small logs placed across the road and covered with dirt, thus making a very bad obstruction in the roadway.

The specifications of the improved roads of the county as recorded give but little definite instructions as to the drainage conditions. The following are the conditions as set forth in the reports which apply in a general way to most of the improved roads in the county: "The drainage shall be by side-ditches in all excavations and in all embankments under 1 foot. These ditches shall be 1 foot wide at the bottom, 3 feet wide at the top and 1 foot deep, and are to incline parallel with the grade lines shown on the profile. Side-hill cuts are to be channeled off at the first suitable depression. The cross drainage shall be by the best socket sewer pipe at least 22 feet long and of the size and at the location shown on the profile, and the tiling must be laid deep enough to be out of danger of breakage by travel, and to carry off water."

Bridges.—No detailed examination of the bridges was attempted, though note was made of their general character and condition. They may be divided into 3 classes—wooden, iron, and stone. Under the head bridges is included not only bridges proper, but also culverts and smaller drains. The majority of the small bridges, culverts and drains are of wood. They are in

Plate XXI.



Steam drill used in drilling for blasting in road-metal quarries and in places where deep cuts are to be made.

Steam road roller used in Bloomington. Weight 12 tons.

various stages of repair varying from those newly built to those over which it is unsafe to ride. Over some of the larger streams are enclosed or covered wooden bridges. Iron bridges are, however, fast replacing the longer wooden spans, and stone and sewer tile are replacing the smaller bridges, culverts and drains. The bridge specifications in general are as follows: "All bridges shall be constructed according to the section on Exhibit 'X.' The masonry shall be of the kind commonly known as broken range. No stone shall be used that is less than 6 inches in thickness, 1 foot in length, and equal to ½ the thickness of the wall in width, and at least every third course shall be of a width or length equal to the full thickness of the walls. The bulk-heads for sewer tile shall be 1 foot thick and shall be capped with a stone their full length and not less than 6 inches thick and of a width sufficient to over-jet the walls on either side or end. All of the above to be of the size and style as shown in section on Exhibit 'X.' * * * All stone shall be laid in the mortar of 1 part cement and 2 parts of clean sand. Any mortar which has been mixed and allowed to set will not be permitted to be remixed and used. * * * The box culverts at stations Nos. 1, 2, 3, etc., shall be covered with stone 6 inches thick and of a width sufficient to lap 1 foot on each wall. * * * All wooden culverts shall be constructed of sound white oak timber of a strength sufficient to carry 60 pounds to the square foot, with a safety factor of 4. The floors of the culverts shall be raised 1 foot above the grade line. All culverts shall be provided with hub-guards and hand-rails and shall be eighteen feet wide. The superstructure of all wooden culverts shall be built of rubble masonry in the following manner: Walls long enough to bear up the structure placed upon them shall be built; to these walls shall be joined wing walls extending from the main walls at an angle of 45 degrees for a distance of 9 feet. These walls may be stepped by permission of the engineer in charge. All walls are to be laid in good cement mortar."

In some of the stone abutments there are traces of weakness and disintegration, caused by the water and the action of the frost. One of the items of cost in the construction of a bridge is that of the abutments, upon which the stability of the whole structure depends; it is therefore important that they be properly located,

Plate XXII.

View on Eleventh Street and Vernal Pike extension, showing foundation stone and placing of top dressing.

Showing that fine gravel used as top dressing for stone on steep grades is soon deposited at foot of hill.

and this can be done only after a careful study has been made of the proposed bridge site. With the great supply of stone at hand in Monroe County the bridges as they are being built may at a very reasonable cost be made with unyielding foundations.

Road Materials.

The essential qualities of a good road surface are hardness and smoothness at all times. These qualities are obtained, first, by proper construction; second, by the selection of a good road material; and it is a matter of very great importance to determine before making the road what is the best available material to use upon its surface. The forces tending to destroy roads must first be considered in order to see what qualities the stone must have to resist them; such forces are first, the wear and tear of travel; second, the forces of nature.

Monroe County is abundantly supplied with stone and gravel, such as are of various values as road material, and are therefore of much significance to the road builder. Not only do the physical characteristic of the materials composing the roadbed largely affect the permanency of the traveled way, but the character and distribution of the materials of the different portions of the county determine the quality of the road metals which are actually placed upon the roads of the county. The character of the roadbed is of great importance, and depends largely upon the underlying geological formation. The limestones, sandstones, gravels, sand, shales and clays present various conditions which are difficult to deal with, both in the preparation of the bed and in the surfacing of the road. Every year thousands of dollars are spent for the construction and repair of the roads and it is the duty of the people of the county to make sure that the best methods of construction and the very best material at hand are used, in order that the cost of maintenance may not be too great.

The specifications of the improved roads of the county as to the metal used are as follows: "The metal to be used upon the road shall be of the best hard limestone * * * and the contractor shall examine the quarries and satisfy himself as to the nature and location of the material before he bids * * * the gravel used shall be of the best stream gravel."

In many places, however, the "best materials" have proven to be of little value, and in passing over the roads of the county, one can see the actual value of the materials used, as regards the resistance to wear and the cementing value. A great saving can be made if it is known before building the road what is the best material to use. Although experience is the best test of road materials, it would take several years with very accurate records to get results of any value, and the method would not be a practical one. Laboratory methods must therefore be used to determine the wearing qualities of a road metal and its resistance to the weather, and such results are of great value, although they may not be as accurate as might be desired.

With the descriptions of the road materials of the county given below will be found tables of laboratory tests made in the Road Material Laboratory of the United States Department of Agriculture, Washington, D. C. These tests were made at the request of W. S. Blatchley from samples taken from the locations described below. The results of the tests and the actual showing of the materials on the roads of the county, as well as could be ascertained by a close study of the roads and the records available, are in very close accord, and such tests will no doubt be of practical use in the construction of the roads of the county.

LIMESTONES.

The Salem or Bedford Oölitic Stone.—This stone comprises an irregular strip through the county, beginning a little south of the river at the northwest corner of the county, and extending in a southeasterly direction, varying in width from 1 mile to 3 miles near Bloomington. From there the belt turns slightly to the southwest and becomes wider as it approaches the southern limit of the county, until it is almost 6 miles in width. The chief value of this stone is for building purposes, and for use in making Portland cement. This stone has been used to some extent on the road passing through the section of the county where it is found. The stone is soft and does not give a lasting roadway; the cementing quality is good, but it will not stand the grinding action of the wheels as do the harder stones. The planer dust, which can be had from the mills for the cost of transportation, has been used

Plate XXIII.

View on West Pike at location of power house and lake of city water works.

View on Bloomington-Columbus Pike, near Stobo P. O. Foundation, limestone; top-stream gravel.

in places as a top dressing for other stone. Where this stone has been used on much traveled roads, rapid wearing produces a surface of dust that becomes often intolerable during dry and windy periods. When first placed upon the roads the "oölitic" stone is very white, but soon becomes of a dull slaty color.

Although this limestone is not an ideal one for road purposes it is the most abundant and accessible in the region in which it occurs and can well be recommended for roads where the heaviest traffic is not present. It is very certain that a more extended use of this stone will be made on the roads through the quarry districts. Roads of greater durability could be constructed if the foundation were made of the "oölitic" stone and the top dressing be of harder limestone or of the cherty and quartzitic gravel found in the same parts of the county; this gravel is a good binder and offers a strong resistance to wear.

Results** of Physical Tests of the Salem or Bedford "Oölitic" Limestone from the property of the Hunter Valley Quarries, Bloomington.

Specific gravity	2.4	**French coefficient of wear**	3.7
Weight per cu. ft. (lbs.)	149.7	**Hardness**	-47.5
Water absorbed per cu. ft. (lbs.)	4.44	**Toughness**	4
Per cent. of wear	10.8	**Cementing value**—Dry	18
		Wet	63

"A very soft limestone, very low in toughness and resistance to wear, developing a good cementing value. Best suited for country-road traffic." —Page.

A sample of the stone was analyzed by the chemist at the same laboratory, with the following results:

***Analysis** of Bedford Oölitic Limestone from Hunter Valley Quarries, Bloomington, Monroe County.*

	Per cent.
Alumina (Al_2O_3)	Trace
Lime (CaO)	56.10
Magnesia (MgO)	Trace
Insoluble in hydrochloric acid	1.12
Loss on ignition	42.50
Total	99.72

The Harrodsburg Limestone.—This limestone is the surface stone along the eastern outcrop of the "oölitic," where it comprises a belt from 3 to 5 miles in width. To the east there are detached patches of this stone capping many of the hills of the Knobstone.

*For standard of comparison see p. 79.

This stone is very fossiliferous, and also contains great numbers of geodes and masses of chert. The Harrodsburg, although not a hard limestone, is a much more durable road metal than the "oölitic." It has been used quite extensively on the roads of the county with fairly good results. The residual clay of this limestone is very stiff, and a small amount of the clay used with the crushed stone aids greatly in binding the particles together.

In parts of the county where the Harrodsburg limestone was once the surface stone, the geodes and cherty masses are found in considerable quantities along the streams, and are of value as road metal. The Upper Harrodsburg is massive but not so firm and durable as the Lower.

Results of Physical Tests of the Upper Harrodsburg Limestone from land of Indiana University, Bloomington.

Specific gravity	2.7	French coefficient of wear	3.8
Weight per cu. ft. (lbs.)	168.4	Hardness	—14.5
Water absorbed per cu. ft. (lbs.)	3.32	Toughness	6
Per cent. of wear	10.6	Cementing value—Dry	19
		Wet	49

"A very soft limestone, low in toughness, with very low resistance to wear. Develops good cementing value. Best suited for country-road traffic."—Page.

Results of Physical Tests of the Lower Harrodsburg Limestone from roadside quarry on north pike, one and one-half miles north of Bloomington.

Specific gravity	2.6	French coefficient of wear	7.5
Weight per cu. ft. (lbs.)	165.3	Hardness	—3
Water absorbed per cu. ft. (lbs.)	.97	Toughness	7
Per cent. of wear	5.3	Cementing value—Dry	23
		Wet	62

"A soft and brittle limestone, with rather low resistance to wear, but good cementing value. Best suited for highway and country-road traffic."
—Page.

Samples of both the Upper and Lower Harrodsburg limestones were analyzed at the same laboratory, with the following results:

Analyses of Upper and Lower Harrodsburg Limestones from Monroe County.

	Upper stone.	*Lower stone.*
Alumina and iron oxide ($Al_2O_3+Fe_2O_3$)	0.65	0.63
Lime (CaO)	52.95	50.50
Magnesia (MgO)	0.20	2.50
Phosphoric acid (P_2O_5)	..	0.32
Insoluble in hydrochloric acid	3.76	4.53
Loss on ignition	42.04	41.65
Total	99.60	100.13

Plate XXIV.

Stone road on which no screenings were used. One mile south Cross-Roads Church.

Outcrop of stone in roadway in the southwest corner of Bloomington.

The Mitchell Limestone.—This limestone extends in the main from the north to the south side of the county along the western edge of the Oölitic belt, and west almost to the county line to where the sandstones appear as the chief surface stones with limestone outcropping here and there. The Mitchell limestone consists of massive, compact layers of dark blue and gray limestones, with interbedded impure and fossiliferous limestones, shales and chert. In the main this is a very hard limestone and is of great value as a road material. It has been used chiefly in the construction of the streets in Bloomington and on several miles of the best improved roads of the county. As far as it is possible to determine from statistics now at hand and by the actual wear on the roads the Mitchell limestone is the best road material in the county.

Results of Physical Tests of Upper Mitchell Limestone from the land of James Blair, along the Ellettsville pike and Maple Street extension, Bloomington.

Specific gravity.................	2.6	French coefficient of wear.	13.4
Weight per cu. ft..........(lbs.)	165.3	Hardness.................	9.3
Water absorbed per cu. ft..(lbs.)	1.7	Toughness................	13
Per cent. of wear..............	3	Cementing value—Dry....	30
		Wet....	41

"A tough, hard rock with a fairly good resistance to wear and cementing value. Suited for highway and suburban traffic."—Page.

*Results of Physical Tests of the Lower Mitchell Limestone from the road-metal quarry of F. M. Robinson, west of the cemetery, Bloomington.**

Specific gravity.................	2.6	French coefficient of wear.	11.5
Weight per cu. ft..........(lbs.)	162.3	Hardness.................	10.5
Water absorbed per cu. ft..(lbs.)	2.16	Toughness................	12
Per cent. of wear..............	3.5	Cementing value—Dry....	14
		Wet....	74

"A very hard limestone, rather high in toughness and resistance to wear, developing a good cementing value. Should give excellent results under highway traffic."—Page.

*For standard of comparison see p. 79.

Plate XXV.

View Bloomington-Ellettsville Pike, where creek crosses road.

Showing the effect of summer showers on road in the residual clay of Harrodsburg limestone.

Samples of both the Upper and Lower Mitchell limestones were analyzed at the same laboratory, with the following results:

Analyses of Upper and Lower Mitchell Limestones from Monroe County.

	Upper stone.	*Lower stone.*
Alumina and iron oxide ($Al_2O_3+Fe_2O_3$)	.50	.50
Lime (CaO)	55.00	47.00
Magnesia (MgO)	Trace	5.29
Phosphoric acid (P_2O_5)	Trace	..
Insoluble in hydrochloric acid	1.84	5.44
Loss on ignition	42.69	42.03
Totals	100.03	100.26

The above mentioned quarry is the largest road metal quarry in the county. It has furnished much of the material for the city streets, for considerable of the country roads west of town, and during the past year has furnished several hundred yards of broken stone for repair work on the improved roads of the county within reasonable hauling distance. The chief reasons for this quarry now being so largely worked are its nearness to the city of Bloomington, the quality of the stone, and the saving in expense in moving crushers, etc. (see description of road machinery).

The quarry on the property of James Blair was but recently opened, but it will prove to be a quarry of value, because of the value of the stone, and the small amount of stripping necessary to make the stone available. Two pieces of roadway just completed will show the value of this stone on much traveled ways, i. e., Eleventh Street extension to the Vernal Pike and the Maple Street extension to the Ellettsville Pike.

The showing of the tests and the durability as shown upon the roads where the stone has been used, should lead to the Mitchell limestone being made the important source of road material.

Gravel.

In the different parts of the county there are various classes of gravel of more or less value as road material. All these gravels have been used to some extent as road metal. In themselves they are not first-class, but when used as a binder or top dressing with crushed stone are very serviceable. Short distances have been improved with these gravels alone, but in most places they have been

used with the stone, and in other places have been used by the farmers and supervisors to repair earth roads.

The best of these gravels is a cherty gravel found in considerable quantity along Jack's Defeat Creek, especially in the vicinity of Stinesville. This material has been used on the roads in part around Stinesville, Ellettsville, and on the road between Ellettsville and Mt. Tabor. When tested it shows a cementing value when dry of 23; when wet, 54.

"Is a gravel which develops a good cementing value. Will do well for gravel roads or as a binder."—Page.

Along Little Richland Creek and its branches is found a gravel composed of chert, geodes, sandstone, fragments of limestone and shale. This is plentiful south of Ranard Schoolhouse, section 29, Richland Township. This mixture is very suitable for road material and has been used on the improved roads in sections 20, 21, 28, 29, 30, 31, 32 and 33, Richland Township.

Along Big Richland Creek and the streams south there is a very similar gravel, but composed chiefly of sand, and fragments of sandstone and limestone. This has been used in sections 31, 32 and 33 of Richland Township, and wherever gravel has been used in the townships south.

In the southeastern part of the county is a gravel which consists chiefly of geodes, chert, and the red residual clay of the Harrodsburg limestone. There is also a considerable amount of sandy gravel from the Knobstone. These are used on some of the roads of Salt Creek Township.

Farther north in the vicinity of Stobo and still farther north is a gravel composed of sandstone, geodes and shale. It has been used on the roads near Stobo and along Stephen's Creek.

In the northeastern part of the county there is a supply of gravel very similar to the last one mentioned, but also there is in addition glacial gravel. North of Hubbard's Gap, in Marion Township, are deposits of glacial material. This is found most plentiful along Robert's Creek and its tributaries and farther west along the valleys and the streams tributary to Hacker's Creek. Also south of the gap in the streams of Honey Creek is found sufficient glacial material to give durability to the stream gravel above mentioned, i. e., that consisting of sandstone, geodes and shale. No use worthy of mention has been made of this material.

From the description of the materials given above it may be seen that it is possible for Monroe County to have a varied assortment of good roads. There are no improved roads in Marion and Polk townships, and of the total mileage of improved roads more than 50 per cent. is found in the three townships of Bloomington, Perry, and Richland. Nine well improved stone roads lead out of the city of Bloomington to the different parts of the county; of these the Bloomington and Whitehall road is probably the best, and the north pike is the one which has the most picturesque scenery. All these roads are much traveled, the wear and tear of the vehicles is very great, and too much care can not be taken in the construction and maintenance of such roads. The total mileage of improved roads as given is exclusive of city streets and roads improved by the farmers of the various townships.

METHODS OF CONSTRUCTION AND MACHINERY USED.

The Road-bed.—The right of way for most of the roads improved is 40 feet in the clear. The road-bed proper in most cases is required to be 20 feet in width with the center line 6 inches higher than the outer edge. Other matters in regard to the road-bed must be determined by the location under consideration, by the material passed over, the natural drainage, the grades, etc.

Surfacing.—The specifications state that the metal placed upon the road shall be of gravel or crushed stone. Where the stone is used it is to be crushed so that no piece will cube greater than 2½ inches or of such a size as will at its greatest diameter pass through a 2½-inch ring. The advantage of uniform size is explained by the fact that the strength of a broken stone road consists in the firmness with which the different pieces are held together. If the stones are of various sizes, smaller ones will be found between larger ones, preventing the latter from coming together. "The metal is to be placed upon the road 12 feet wide or 6 feet on each side of the center line. It shall be 1 foot deep at the center and 6 inches deep at the outer edge. The metal shall be banked up at the sides with earth extending at least 2 feet from the edge of the metal. The metal shall consist of 2 courses of stone—the first course shall be 9 inches deep and crushed so that no piece will cube greater than 2½ inches; the top course shall be of screenings 3 inches deep."

The roads formerly built in the county have not been rolled with a steam roller. The roads which have been constructed would require from 1,600 to 2,000 yards of stone per mile and the total cost of the road would approximate $2,500 per mile. But where there is the heaviest traffic the grade should be somewhat more than 20 feet, we will say 30 feet, with the metal 20 feet in width, and should be well rolled with a steam roller. Such a piece of road has been built from the corner of Thirteenth and Maple streets to the Ellettsville Pike. Such a road would cost from $4,000 to $5,000 per mile, but the increase in durability and the small cost of maintenance would make it advisable to construct such roads where wide roads are necessary.

Steam Rollers.—As stated above, the steam roller has not been used on the improved roads of the county outside of the limits of the city of Bloomington, except on short extensions built in 1905. Such a roller as is used on the streets of Bloomington would now cost about $2,500. The weight is 12 tons. Such a roller is capable of climbing any grade that should be permitted on an improved stone road. The engineer in charge would be paid about $2.50 per day, and he could roll about a mile of road in a day or about a half mile of surfacing in a day. Although the first cost would be great the roller is very lasting, and the better condition of the roads, and the saving to vehicles and horses, would more than compensate for the original cost. The amount of fuel used would be about 600 pounds of coal per day. The roller should be used both in the construction and the repair of the roads. The road-bed should be carefully rolled, then the crushed stone placed upon the surface and rolled and finally the screenings be put in place and rolled. Every road is made smoother, harder, and better by rolling. If the rolling is not done in damp weather the surface should be sprinkled in order that the best cementing results may be had.

Crushers.—The machines used in the county for crushing the stone for road purposes are shown in the illustrations accompanying this report. These crushers have a capacity of 100 yards in 10 hours. This material is crushed and the screen at the top of the carrier separates the material. The stone is crushed and delivered on the road for $1 per cubic yard. In the construction of a new road a quarry is usually opened at a place that will make

the material most available, but on account of the cost of stripping, moving, crushing, etc., the owner of a crusher can not afford to move to a new place unless he has a contract for at least 500 or 600 yards. Thus for repair work it is often necessary to haul the crushed stone for some distance, and often at a small additional cost per cubic yard.

Steam Drill.—The steam drill as shown in the illustration is used in the quarry to drill into the stone for the purpose of blasting the material in order to get it ready for the crusher. The drill is used in many places where roads are being constructed and it is necessary to cut through the stone to lessen the grade.

Other Tools.—The graders, scoops, plows, shovels, picks, mattocks, sledges and axes are the other necessary tools. "The contractor is required to furnish all tools, material and labor necessary for the construction of the road. All work must be done in strict accordance with the profile and to the satisfaction of the county commissioners and the engineer in charge."

While the success of any particular class of work depends largely upon the use of proper tools and machinery, the amount of improved road machinery owned within the county is very small, and before the county can have the best possible roads it must be supplied with the requisite implements.

Broad Tires.—Wide tires are road makers. It is generally admitted that broad tires are an advantage to the roads, and it has also been proven that they also benefit those using them. The greater number of tires used in the county are less than 3 inches wide. Most of the tires are 2 and 2½ inches in width, and some are only 1½-inch tires; such are very injurious to the roads.

Survey Records, Mail Routes, Guide-boards, Double Track, etc.

Plats and Records.—All the roads should be surveyed and accurate plats and records preserved for future reference. The property boundary lines should be made very definite. Often the "middle of the road" is a very indefinite line, which changes position every time a fence is repaired.

Mail Routes.—There are in the county fifteen rural routes, including one that goes out from Gosport and touches the northern

side of the county. These routes serve approximately 7,500 persons.

Guide-boards.—There are but few guide-boards in the county, and a greater number of these guides placed at the cross-roads would be great convenience to travelers. They should be well made. The habit of using guide-boards as a target and destroying them is inexcusable, and persons injuring them should be punished.

Double Tracks.—While there are no roads in the county where double tracks were originally constructed, there are places where double tracks have been formed by persons seeking to keep off the stone road in the dry summer weather. The best example of this is on the Columbus road east of Bloomington. These side tracks are a saving to the stone road. The dirt roads wear down more rapidly and are soon at a lower level than the stone road, and are sometimes cut so far below as to form a dangerous bank.

The stone roads constructed of the best material and kept in perfect condition are the most satisfactory, the cheapest, and most economical roads that can be constructed. The good roads being constructed will lead the people of the county to appreciate good highways and gradually all the important roads will be improved. When the economic value alone of the good roads is considered it will be seen that the money spent is paying handsome dividends.

SECTION XIV.

THE ROADS AND ROAD MATERIALS OF A PORTION OF SOUTHWESTERN INDIANA.

EMBRACING THE COUNTIES OF DAVIESS, PIKE, GIBSON, POSEY, VANDERBURGH, WARRICK, SPENCER, DUBOIS, PERRY, AND CRAWFORD.

BY A. E. TAYLOR.

The area treated in this section comprises about 3,845 square miles of southwestern Indiana and embraces the counties above mentioned.

Although this portion of Indiana has been noted for its poor roads and cheap land, the efforts put forth in road improvement during the past 6 years have wrought a marked change. The miles of improved roads have been more than doubled, and several counties which previously contained no road improvement now have from 20 to 90 miles. The farms along these roads have also become more valuable; not merely on account of an available market at the time of the year when prices are at their best, but because of numerous improvements in buildings, fences and tiling. The improved road is truly a great incentive to industry. To fully appreciate this, one only needs to pass from a neighborhood of southwestern Indiana where the roads have been improved and the farms have been made to correspond, into another section where the roads are unimproved, and note the old dilapidated buildings and fences. The land is just as fertile as that along the improved road, but the farmer is discouraged because he can not market his crops, except in the busy season of the year, at a time when the prices are at their lowest. He can not send his children to the high school 6 or 7 miles distant unless he goes to considerable expense and at the same time be deprived of their presence. He can not get the benefit of the free rural delivery, and is thus

shut off, to a considerable extent, from what is going on about him. These are a few of the many reasons why he has not the ambition and pride to improve his farm and home.

Kind of Road Materials.

The available road materials of this area are gravel and limestone. The gravel, as the writer will generally use the word, will include, strictly speaking, the following: (a) A fine medium sand, 1-100 to 1-40 inches in diameter; (b) a medium sand, 1-40 to 1-8 inch in diameter; (c) a coarse sand, 1-8 to 3-8 inch in diameter; (d) a roofing pebble, 3-8 to 7-8 inch in diameter; (e) a gravel, 7-8 to 2 inches in diameter. Anything larger will be termed a boulder, and any sand smaller than 1-100 of an inch will be known as a fine sand. Only when the word gravel is used to mean the percentages of the various sizes of material in a deposit, will it mean from 7-8 to 2 inches; as, for example, when we say 10 per cent. coarse sand, 50 per cent. roofing pebble, 30 per cent. gravel, and 10 per cent. boulder. The word ferruginous means a rock containing red iron oxide; argillaceous means clay-like, and argillite is an indurated form of shale. Phenocrysts refers to the large crystals or grains in the fine grained rocks.

Gravel.—With the exception of the flood plains, terraces and bars of the Wabash, gravel beds of economic importance are rarely found. Besides the deposits along the Wabash, the only workable ones known are located in a stream bluff of Gibson County, 1 mile north of Princeton; in the terraces of Black River in northern Posey County; in some bars of the Ohio River a mile east of West Franklin; and possibly in the bluffs of the Ohio at Cannelton and Tell City. The only deposits worthy of our notice here are those along the Wabash and Black rivers.

These deposits are mingled with a large portion of fine sand, which has to be screened. They are also almost free from clay, which causes them to be extraordinarily slow in packing. This slowness in packing permits the gravel to rub together and work off at the sides of the road, thus causing a rapid wearing down by friction and a frequent grading of the road. If 6 to 10 per cent. of clay in some way could be supplied it would cushion the individual pieces from one another, thus doing away with a large

amount of friction, and would keep the material in its place. Furthermore, it would very soon cause the road to become hard and smooth, thus getting rid of the cumbersome hauling through a loose gravel. Outside of the absence of clay, this gravel is of a very good quality. The amount of oxidation is low and the rock percentages are about 43 limestone, 18 chert, 14 granite, 11 quartz, 6 diorite, 6 shale, 1 argillite and 1 slate, thus giving us a high percentage of the harder and more durable rocks.

Limestone.—In this portion of Indiana limestone is much more available, has a greater durability, is more used and gives better satisfaction than the gravel. It is found, more or less, in all of these counties; the limestones of the Lower Carboniferous or Mississippian and Coal Measures occurring in Crawford, Perry and Dubois counties, and the Coal Measure limestones in the remainder of the area.

The Coal Measure limestones appear in a great variety of colors and qualities. A black dolomitic limestone, with a low degree of hardness, a fair degree of toughness and durability, and a good cementing value, is found in northern Pike and Gibson counties. A gray, medium grained rock, with a medium hardness, occurs in Posey, Vanderburgh and southern Gibson counties. A hard, tough ferruginous limestone, with a high cementing value, outcrops in Warrick and Spencer counties. The Huron rock of the Lower Carboniferous, which is found in the stream beds and bluffs of eastern Perry, northeastern Dubois, western and central Crawford, ranges from a blue, fine grained to a gray, coarse grained stone. Taken as a whole, the durability of this rock is probably superior to those of the Coal Measure rocks.

The limestone, which is being used most in this area for road building purposes, is the Mitchell of the Lower Carboniferous. It occurs in eastern Crawford County, and is quarried on a large scale at Marengo and Milltown. Several hundred miles of road have been built with this stone during the last 6 or 7 years. In general it is showing, where the roads are properly graded and ditched, a very fair durability. There is, however, a considerable difference in the character of the road metal obtained from the Mitchell formation. Some of the material is a bluish, fine grained stone; other has a grayish color and is medium or coarse grained. Some of this rock, which is inferior in quality, contains streaks of

iron oxide. These streaks are lines of weakness, along which the stone is likely to break upon being subjected to pressure or a blow.

A great many localities of this area are from 5 to 15 miles from a railroad, but at the same time have more or less limestone outcropping in the stream beds and valley sides. These same neighborhoods, in almost all cases, are without any improved roads. For such the writer will suggest a portable crusher that can be moved from place to place with little expense. With this 10 men can turn out from 40 to 60 cubic yards per day at a cost ranging between 50 and 70 cents per cubic yard. At such a cost a rather inferior material might be the most practicable for the local use.

DAVIESS COUNTY.

Area in square miles	430
Population in 1900	29,914
Miles of public roads	860
Miles of improved roads	106
Percentage of roads improved	12.3
Miles improved with gravel	70
Miles improved with crushed stone	36
Average original cost of gravel roads per mile	$1,875
Average original cost of stone roads per mile	$2,125
Total original cost of improved roads	$208,050
Miles of improved roads (gravel) built in 1905	70
Miles of improved roads (stone) built in 1905	36
Miles of improved roads (gravel) contracted for 1906	33
Miles of improved roads (stone) contracted for 1906	10
First improved roads built	1903
Satisfaction of farmers with investment in improved roads	Good
Authority	Thos. Nugent, County Auditor

Separated from the Illinois State line by Knox County is Daviess, in the southwest portion of Indiana. The West Fork of White River forms its western and the East Fork its southern boundary, the two uniting at the southwestern corner.

Almost the entire county has for its surface formation the Coal Measure rocks, the Mansfield sandstone outcropping along the streams of the northern and eastern parts. The limestone, which outcrops only in a few places near the East Fork of White River, will be taken up later. The drift, which ranges between

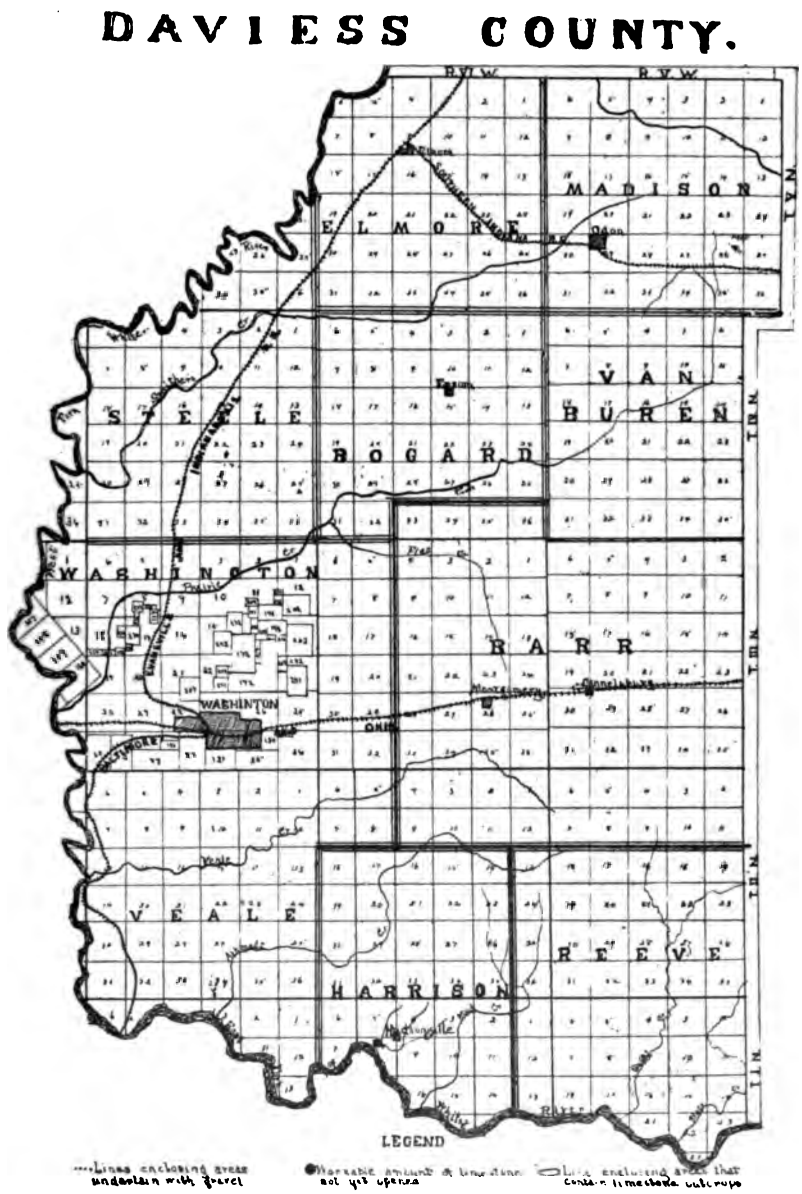


Fig. 54. Illustrating the distribution of road materials in Daviess County.

0 and 90 feet in thickness with an average of less than 20 feet, covers most of the natural outcrops.

The topography of the northeastern part of the county is broken by sandstone ridges, but advancing west and southwest this quickly gives way to a rolling country, and this in turn to a level surface. Numerous prairies are found along Smither's and Prairie creeks, where lakes or swamps once existed. In the southern portion of the county, the larger tributaries of the West Fork of White River have cut very pronounced valleys, which give a hilly surface.

Three railroads traverse this county, the Southern Indiana from east to west across the northern third, the B. & O. S.-W. from east to west a little south of the center, and the E. & I. the western third from north to south.

For road building materials, this is one of the poorest counties of the State. The only known sources are the gravel deposits in the bars and flood plains of the West and East Forks of White River, in small pockets along Prairie Creek and near Cannelsburg, and the limestone at Hudsonville and at a few places along the East Fork of White River.

Gravel.

A gravel bar belonging to T. Hill is found in the West Fork of White River 1 mile north of Maysville. This bar has an area of 1½ acres, and is made up of gravel and fine sand, thoroughly washed. The sizes of this material are 45 per cent. fine to a fine medium sand, 45 per cent. fine medium to coarse sand, 6 per cent. roofing pebble and 4 per cent. gravel; and the rock percentages are 41 limestone, 30 crystallines, 11 argillaceous chert, 10 slate, 6 chert and 2 sandstone. Before this material can be used for road purposes it has to be screened. The absence of clay makes it very slow to pack, and requires frequent grading to keep it from working off from the roads. Until it becomes packed traffic over it is carried on with considerable difficulty.

Immediately west of Cannelsburg and north of the B. & O. Railroad, a good quality of gravel is reported beneath the groundwater level. Tests have shown the extent to be several thousand square yards and the stripping to be from 10 to 15 feet. The depth of the bed has not been determined.

In the flood plain of Prairie Creek the writer made 4 tests by driving down a 1½-inch pipe on the Brady farm in the east-central part of section 27 (4 N., 6 W.). He tested to a depth of 10 feet and found in the first test 5 feet of a material running 5 per cent. clay, 3 per cent. fine medium sand, 2 per cent. medium sand, 5 per cent. coarse sand, 35 per cent. roofing pebble, 50 per cent. gravel; 2 feet of mud with a little gravel; and 3 feet of a material running 10 per cent. fine medium sand, 25 per cent. medium sand, 30 per cent. coarse sand, 30 per cent. roofing pebble and 5 per cent. gravel. No bottom was reached. Seventy feet from this test another showed 4 feet of stripping, 4 feet of a material made up of ½ clay and ½ medium sand, and 2 feet of a good sized gravel. The other 2 tests showed only a clay, fine sand and fine medium sand. All of the gravel lies beneath the ground-water level. Further tests may possibly locate a practicable deposit.

An average of 4 samples gives the following rock percentages: 40 sandstone, 19 chert, 14 quartz, 12 argillaceous chert, 12 granite and 3 andesite. All of these rocks are highly weathered, and the sandstone is useless as a road material. Some of the granite and andesite are so oxidized that they can be crumbled in one's fingers. Although this vicinity is 7 miles from a railroad and no other road material is known, the writer believes that unless a larger deposit is found and a better quality of gravel, it would be cheaper in the long run to haul a good crushed limestone from the nearest railroad switch.

The gravel used on the Washington and Evansville road near Washington was shipped from Elliston, Greene County, where it was obtained from a bar in the West Fork of White River. The rock percentages are 68 limestone, 18 crystallines, 8 argillaceous chert, 4 shale and 2 chert. This material is of a good size and little oxidized, but is too low in clay to pack readily. However, when it does become packed, it makes a smooth and durable road for a gravel, but the wearing qualities are not equal to a good crushed limestone.

Limestone.

The only known limestone that is at all promising for a road metal is found at Hudsonville and in the north-central part of section 8 (1 N., 6 W.), in the bed of a tributary to the East Fork of White River. The limestone at Hudsonville is found outcropping in the side of a small stream valley. It is also found 70 yards back from the valley, 32 feet beneath the surface, in the side of a dug well. Here 3 feet of it were passed through. It has a gray color, is hard and contains no impurities. It is very probable that careful investigation will locate enough of this material to pay for setting a portable crusher.

The stone of section 8 is a dark, soft limestone, containing some shale and other impurities. Although a large quantity seems to be available, the writer does not think it advisable to use it for a road metal, because of its softness and impurities. It would not be likely to be very durable. It may be that other portions of this formation are of a better quality, since a similar colored limestone, without impurities, is being quarried and crushed a little farther down the river in Pike County. This rock seems to be durable and is giving good satisfaction.

Ten miles of road in the vicinity of Odon have been built with the Bedford stone. This stone seems to be rather soft and is not giving the best of satisfaction.

PIKE COUNTY.

Area in square miles	336
Population in 1900	20,486
Miles of public roads	1,200
Miles of improved roads	36.4
Percentage of roads improved	3
Miles improved with gravel*	None
Miles improved with crushed stone	36.4
Average original cost of stone roads per mile	$2,530
Total original cost of improved roads	$92,100
Annual cost for repairs per mile on stone roads 2 years old	$100
Miles of improved road (stone) built in 1905	10
First improved roads built	1902
Satisfaction of farmers with investment in improved roads	Good
Authority	T. W. Basinger, County Auditor

*About one-half of the roads have a top dressing of White River gravel.

This county lies in the southwestern part of the State, south of Daviess and Knox, west of Dubois, north of Warrick and Gibson, and east of Gibson. White River forms the northern boundary and drains the northern third. Patoka River flows from east to west across the center and drains the greater portion.

The bed rocks of the entire county belong to the Coal Measures of the Carboniferous Period. The drift covers these in the northern portion. The surface near White River is dissected by the drainage, but south it becomes level or rolling until the slopes and broad bottoms of the Patoka River are reached. South of the Patoka River the land becomes hilly and grows more and more so until the divide between this river and the Ohio is reached.

PIKE COUNTY.

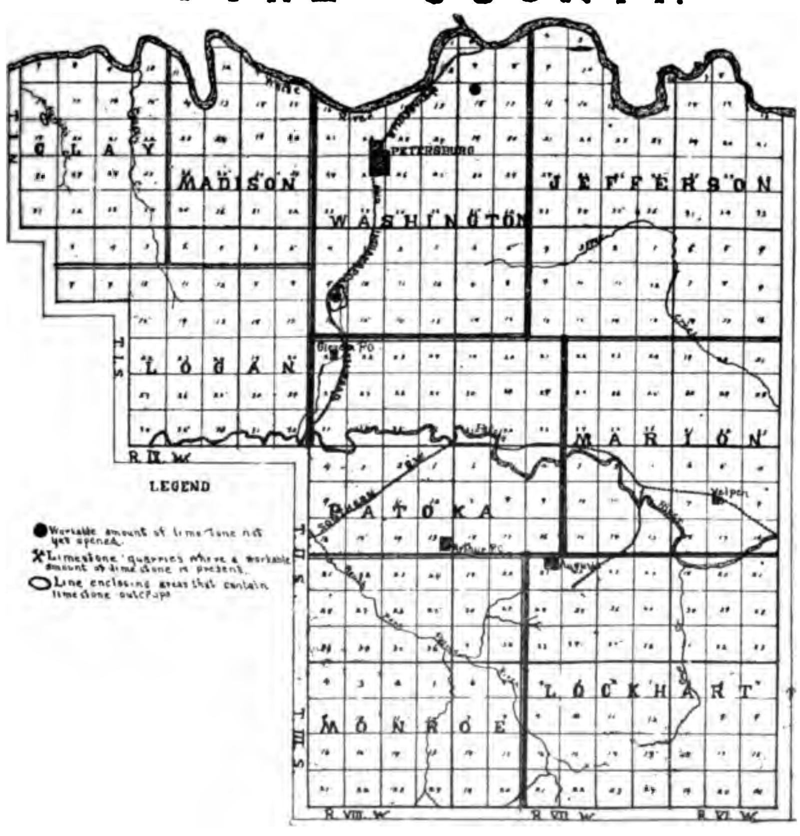


Fig. 55. Illustrating the distribution of road materials in Pike County.

Only 2 railroads are found in this county, the E. & I. crossing from north to south, a little west of the center, and the St. Louis Division of the Southern from east to west near the center.

Road materials are very scarce, no gravel being present except some sand bars of White River 1½ miles northeast of Petersburg, which contain only a low per cent. of gravel. The principal limestone outcrops are within from ½ to 2 miles of the E. & I. Ry. between Hedden and Rogers; along Harbin's Creek northwest of Union, and about a mile northwest of Coats Spring. For road building, part of the crushed limestone is shipped in from Milltown and part is obtained from the quarry belonging to J. M. Kinman, in the northwest quarter of section 13 (1 N., 8 W.), on the land of L. George.

The stone obtained from the Kinman quarry is a black limestone with a medium hardness. This rock has been used on the roads for the past 3 years, and is generally claimed to be wearing as well and giving as good satisfaction as that shipped in. The writer, however, is of the opinion that its durability can be better determined after it has been on the road a few more years, since both this stone and that shipped in are only beginning to wear down. In the quarry it is very well bedded and jointed, occurring in 6-faced prisms with acute and oblique angles between the faces. It has been taken out to a depth of 8 feet. Although tests have not been made, it is very likely that much more than a workable amount is available.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of the Carboniferous Limestone from the J. M. Kinman quarry.**

Specific gravity..................	2.75	French coefficient of wear.	8.1
Weight per cu. ft..........(lbs.)	172	Hardness................	—22.5
Water absorbed per cu. ft..(lbs.)	.81	Toughness................	9
Per cent. of wear..............	4.9	Cementing value—Dry....	24
		Wet....	71

"A very soft but fairly tough rock with a good cementing value. Best suited for country-road traffic."—Page.

Samples of the stone were analyzed at the same laboratory, the results being as follows:

*For standard of comparison see p. 79.

Analysis of Carboniferous Limestone from J. M. Kinman quarry.

	Per cent.
Alumina (Al_2O_3)	2.45
Iron oxide (Fe_2O_3)	.50
Lime (CaO)	9.60
Magnesia (MgO)	2.71
Phosphoric acid	.15
Insoluble in hydrochloric acid	72.06
Loss on ignition	12.14
Total	99.61

On the Joseph McCarty property and adjacent farms in the southeast quarter of section 15 (1 S., 8 W.) are numerous outcrops of a gray limestone, with a medium hardness. Where exposed to the weather it has taken on a very irregular cracking, which is due to a more or less heterogeneous composition and a differentiation in expansion and contraction. At least 200,000 cubic yards of this rock are available.

In the vicinity of the McCarty outcrop all of the roads are dirt and the people are very anxious for improvements. Two sources present themselves, the shipping of stone to the nearest railroad switch, which is about 1 mile west, or the setting up of a small portable crusher at some of the outcrops heretofore mentioned. An examination of the results* of the tests of the U. S. Road Testing Laboratory on a somewhat similar limestone found in a quarry at Laubscher Mills, of Vanderburgh County, may be of some assistance in determining the more practicable source.

Along Harbin's Creek and about a mile southeast of Union, limestone is reported that is similar to this on the McCarty place. The limestone obtained from the drainage canal, about 3½ miles south of Petersburgh, and used in the building of the road in this locality, also appears similar to the McCarty stone.

On about 100 yards of the road, which was built a couple of years ago with the stone obtained from the excavations of the drainage canal, in the northeast quarter of section 16 (1 S., 8 W.), sandstone was used as an experiment. Where the stone of the remainder of the road has scarcely begun to wear down, the sandstone portion is very smooth. This fact is pointed to by many as showing the splendid quality of sandstone as a road building material; but on the other hand it shows it to be very low in

*See p. 992.

its durability and wearing quality. Where the limestone can, for a long time, withstand the grinding and friction produced by the wagon tire and the horse shoe, the sandstone crumbles readily. In Orange, Martin and Greene counties and other places where sandstone has been used as a road metal, it has proven a failure.

GIBSON COUNTY.

Area in square miles	490
Population in 1900	30,099
Miles of public roads	1,350
Miles of improved roads	136.87
Percentage of roads improved	10.1
Miles improved with gravel	31.85
Miles improved with crushed stone	105.02
Average original cost of gravel roads per mile	$2,659
Average original cost of stone roads per mile	$2,431
Total original cost of improved roads	$380,060
Miles of improved road (gravel) built in 1905	5.3
Miles of improved road (stone) contracted for 1906	2.3
First improved roads built	1899
Satisfaction of farmers with investment in improved roads	Good
Authority	Harry R. Embree, County Auditor

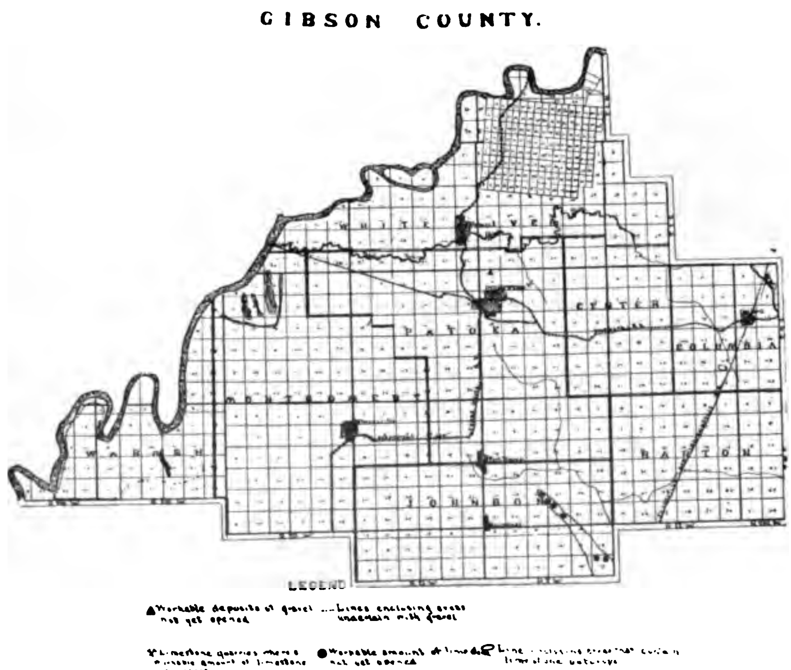


Fig. 56. Illustrating the distribution of road materials in Gibson County.

Gibson County, which is one of the largest of the State, is found on the Illinois and Indiana line in southwestern Indiana. Its extreme length from east to west is 36 miles, and from north to south 25 miles. The entire surface is covered by the Coal Measure rocks of the Carboniferous Period. The topography of the eastern part is hilly, but the western half is gently rolling or level, large areas of bottom land being present.

The transportation facilities are fair. The Evansville & Terre Haute, running north and south, and the St. Louis Division of the Southern, running east and west, intersect at Princeton. The Mt. Vernon Branch of the E. & T. H. cuts the southwestern fourth and the E. & I. the southeastern corner, while the Peoria Division of the Illinois Central touches the southwestern corner. An interurban traction line runs south from Princeton to Evansville.

This county, for southwestern Indiana, is fairly well supplied with road building materials. All along the terraces and flood plains of the Wabash and somewhat of the Patoka River are large deposits of gravel and sand. It is also found in the stream bluffs about a mile north of Princeton. Limestone, which seems to be suitable as a road metal, is found 1½ miles north of Princeton, and in a ridge, which extends for about 5 miles in this county, a few miles north, northeast and east of Warrenton.

At present the main sources of the road materials being used in the county are the limestone shipped from Milltown, the carbonaceous limestone obtained about 1½ miles northeast of Princeton, and the gravel taken from a river bar at Hazleton.

Gravel.

Numerous dug wells have shown abundance of gravel and sand in the broad terraces and flood plains of the Wabash River, but because of its inavailability it has not been used. Because of fineness, screening in almost all cases would have to be resorted to. In both the northern and southern parts of sections 20 and 21, and in the northern parts of 28 and 29 (1 S., 11 W.), dug wells have shown the gravel to occur within from 4 to 20 feet of the surface. In the southeast quarter of section 23 and the east-central part of section 20 (3 S., 13 W.), a good quality of gravel is reported within a few feet of the surface.

Since the greater part of this gravel is beneath the ground-water level, it would be necessary to use a gravel* excavator or endless chain to lift it out.

The gravel obtained from the bars, near Hazleton, is very free from clay, which causes it to pack very slowly on the roads. Gravel, which was put on the road one-half mile east of Fort Branch 18 months ago, has scarcely commenced to pack, and very frequent grading is necessary to keep it on the road. If some clay could be added to this material it would make it pack more quickly and wear longer. The rock percentages are 47 limestone, 26 crystallines, 12 chert, 12 argillaceous chert, 2 shale and 1 slate.

About 1½ miles north of Princeton on the Robert Mitchell farm is a bed of gravel and clay occurring in a stream bluff. In this bluff the bed has been found, by digging and ground-hog excavations, to have a depth ranging between 20 and 90 feet without any bottom being reached, a length of 300 feet and a width of 115 feet. Abrupt gradations of the gravel into clay are frequent. The rock percentages are 26 very hard, cherty argillite, 24 soft shale, 23 ferruginous, argillaceous chert, 10 quartz, 6 indurated shale, 6 sandstone, 3.5 granite, diorite and andesite, and 1.5 limestone, and the sizes range from a fine sand to a medium-sized gravel. The clay, which occurs with this gravel, is very calcareous and makes a splendid cement. It has cemented the gravel so well together in places that it comes out in great masses. On the road this gravel packs very quickly and seems to be very durable. Some of it was used in front of Mr. Mitchell's house, 35 years ago. Since that time it has been driven over a great deal, but still remains as a hard, smooth bed.

Limestone.

Small quarries are located about two miles northeast of Princeton, near the northeast corner of section 4 (2 S., 10 W.), and the central part of the same section. The rock obtained in these is a soft to medium, bluish black limestone, which occurs in beds ranging from 1 to 3 feet in thickness. It is very similar to the stone found at the J. M. Kinman quarry, north of Petersburgh, Pike County. The jointing and bedding is very good. Where the lime has dissolved out along the bedding plains, a ferruginous argillite is left, which is as hard as the limestone.

*See p. 124.

Samples tested at the Road Laboratory at Washington, D. C., showed the following results:

Results of Physical Tests of Carboniferous Limestone from near Princeton, Gibson County.

Specific gravity	2.7	Water absorbed per cu. ft..(lbs.)	1.13
Weight per cu. ft...(lbs.)	168	Cementing value—Dry	21
		Wet	191

"Not sufficient material for tests other than those given above. The stone shows excellent cementing value and should make a very good binder."—Page.

Samples of the stone analyzed at the same laboratory showed its percentage composition to be as follows:

Chemical Analysis of Carboniferous Limestone from near Princeton, Gibson County.

	Per cent.
Alumina (Al_2O_3)	1.36
Iron oxide (Fe_2O_3)	2.44
Lime (CaO)	39.00
Magnesia (MgO)	7.61
Phosphoric acid (P_2O_5)	.15
Insoluble in hydrochloric acid	8.75
Loss on ignition	40.47
Total	99.78

Although sufficient time has not elapsed to get a good comparison of the durability of the Princeton stone with that shipped in from Milltown, it seems to be wearing fully as well. The amount of this material available has not been determined, but it is likely that careful tests will show at least a workable amount.

The limestone ridge extending through sections 21, 22, 28, 27, 34 and 35 (3 S., 10 W.), and 2, 11, 12, 14 and 13 (4 S., 10 W.), was examined by the writer, also that on the W. Karnes place in the southeast quarter of section 21 (3 S., 10 W.). Here the limestone is in small knob-like hills, which rise 15 to 30 feet above the adjacent region. It occurs in beds from 2 to 3 feet thick, has a light bluish color and is well bedded and jointed. It has a fair degree of hardness and toughness, and appears very similar to the rock found at Laubscher Mills, of Vanderburgh County. Although it has not been used in road building, it probably will, because of its availability, be suitable for the local building and repair work.

In the bluffs of the South Fork of the Patoka River, a few hun-

dred yards southeast of where the E. & I. Ry. crosses this stream, and 2½ miles northeast of Oakland City, is a rather extensive outcrop of a gray limestone with similar physical characteristics to that of the limestone found on the McCarty place, in Pike County. Probably 100,000 cubic yards of stone are available in this vicinity.

POSEY COUNTY.

Area in square miles	410
Population in 1900	22,333
Miles of public roads	500
Miles of improved roads	94.24
Percentage of roads improved	18.8
Miles improved with gravel	30.99
Miles improved with crushed stone	63.25
Average original cost of gravel roads per mile	$2,456
Average original cost of stone roads per mile	$3,785
Total original cost of improved roads	$297,520
Annual cost of repairs per mile on stone roads 5 years old	$20
Miles of improved road (gravel) built in 1905	30.99
Miles of improved road (stone) built in 1905	10
Miles of improved road (stone) contracted for 1906	22.2
First improved roads built	1900
Satisfaction of farmers with investment in improved roads—	"Good, and want more"
Authority	S. G. Howard, County Auditor

The county of Posey occupies the southwestern corner of the State. On the west it is separated from Illinois by the Wabash and on the south from Kentucky by the Ohio River. The only surface rocks are those of the Upper or Barren Coal Measures. The topography, except for hills along the river bluffs, is made up of broad flood plains and terraces, and gently rolling uplands. The northern and southern portions of the county are drained into the Wabash by Black River and Big Creek, and the southern third into the Ohio by way of numerous small streams.

The transportation facilities are very good. The Evansville-St. Louis Division of the L. & N. traverses the southern third from east to west, while the Peoria Division of the Illinois Central, with a branch to New Harmony, crosses diagonally the northern third. The Mt. Vernon branch of the E. & T. H. enters at the northeastern corner of the county and runs in a southwesterly direction to Mt. Vernon.

POSEY COUNTY.

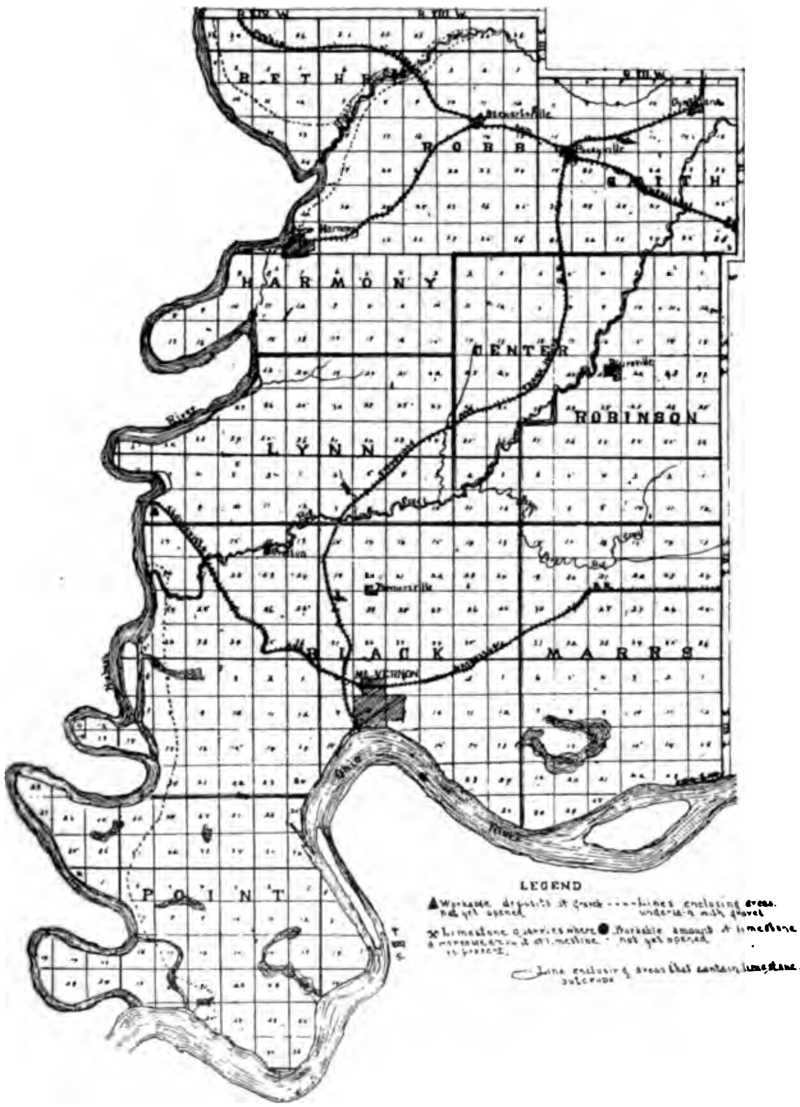


Fig. 57. Illustrating the distribution of road materials in Posey County.

The western quarter of this county is fairly well supplied with road-building material, while the remaining portion, with exception of the region about West Franklin, is almost barren. Large deposits of sand and gravel are found in the flood plains, terraces and channel of the Wabash. The flood plains of Black River also in places contain large quantities of gravel. The principal limestone outcrops are in the bluffs of the Ohio, at and near West Franklin. Smaller available deposits are on the north side of Big Creek, 2½ miles north of Farmersville.

Gravel.

In a river bar of the Wabash, near the ferry that is due west of Mt. Vernon, gravel was obtained for building several miles of road, running east and west between the ferry and Mt. Vernon. It was obtained by screening off 50 per cent. of the fine sand. This road was built 1½ years ago, and is 10 feet wide. It contains 14 inches of gravel at the center and 8 inches at the sides. Although traveled considerably, the material has scarcely begun to pack, and is constantly working off at the sides. This bad quality is due to the absence of clay to pack it. Another unsatisfactory character is its fineness. The sizes are 40 per cent. fine medium sand, 25 per cent. medium sand, 25 per cent. coarse sand and 10 per cent. roofing pebble; and the rock percentages are 43 limestone, 18 chert, 14 granite, 11 quartz, 6 diorite, 6 shale, 1 argillite and 1 slate.

Advancing either north or south from this point, numerous diggings have shown the broad flood plains of the Wabash to be underlain with gravel and fine sand. The greater amount of this gravel is beneath the ground-water level, and would have to be dipped and then screened. These deposits are said to continue, more or less, beneath the flood plains to the Gibson County border.

The best quality of gravel that is being or has been obtained in this county is from the channel of the Wabash at New Harmony. Adam Weikel, with a gravel pump which screens and throws out 225 cubic yards of gravel daily, has contracted to furnish gravel for several miles of road in Harmony Township. He says that only one-sixth of the material is taken, this being that which

will not pass through a quarter-inch screen. This material contains no clay, and for this reason packs very slowly. Its rock percentages, as taken from the average of two samples, are as follows: Fifty-eight limestone, 14 granite, 8 andesite, 5 diorite, 5 chert, 4 sandstone, [illegible] shale, 1.5 cherty argillite and 1.5 quartzite.

The roads built with this material are 10 feet wide, with a thickness of 14 inches of gravel at the center and 8 inches at the sides. The durability of these roads, because of the unoxidized condition of the gravel, will undoubtedly be good.

The amount of gravel that may yet be obtained from the channel and bars of the Wabash for a few miles north and south of New Harmony is estimated to be over a hundred thousand cubic yards. Other large deposits are known to exist farther up, but a gravel pump can not be floated up to them on account of the shallowness of the river.

On the Mumford and Blood farms, in the northwest quarter of section 4 (4 S., 13 W.), is a bed of gravel in the flood plain of Black River, which probably underlies 25 acres. The stripping, where tested, has been from 0 to 3 feet. The average of several samples shows the rock percentages to be 36 limestone, 25 granite, 25 chert, 10 sandstone and 4 shale. The sizes vary greatly, but there is a large amount of material with the following sizes: Twenty per cent. roofing pebble, 70 per cent. gravel and 10 per cent. boulder. This material is not much weathered and would, without doubt, be durable, but its low per cent. of clay will cause it to be slow in packing. With exception of one-half mile of improved road near Griffin, there is no gravel or stone road within seven miles of this location.

Limestone.

In the bluff of the Wabash, one-fourth of a mile southwest of New Harmony, is an outcrop of a gray limestone with a medium hardness. The same quality of stone is reported to outcrop to the extent of 25 acres two miles southwest of New Harmony, in the stream bed of the Wabash. At this place the rock is quite available in dry weather, when the water does not cover this portion. A similar stone, which is available in workable quantities,

is found outcropping in the central and southern parts of section 5 (6 S., 14 W.).

About 3½ feet of a bed of limestone is exposed on the bluffs of a tributary to Big Creek, in the east central part of section 7 (6 S., 13 W.). This limestone has a gray color, a medium hardness, and a good cementing value. It is a good all-around road material, and ranks above the average for southwestern Indiana. Other outcrops of this same quality of stone are reported at various places along Big Creek. Since this vicinity is 7 or 8 miles from any other known road metal, it would probably be the cheaper for the immediate locality to quarry this stone and have it crushed with a portable crusher.

Samples of stone from the property of Wyatt H. Williams were tested at the U. S. Road Laboratory at Washington, D. C., with the following results:

*Results of Physical Tests of Carboniferous Limestone from the land of Wyatt H. Williams, near Mt. Vernon, Posey County.**

Specific gravity	2.7	French coefficient of wear	11.3
Weight per cu. ft. (lbs.)	168	Hardness	11.5
Water absorbed per cu. ft. (lbs.)	1.67	Toughness	15
Per cent. of wear	3.5	Cementing value—Dry	22
		Wet	108

"A rather hard, tough dolomitic limestone which develops an excellent cementing value. A good all-around road material."—Page.

A crushing plant is located at West Franklin, where the limestone outcrops in the bluff of the Ohio. The outcrop has an extent of one mile down the river, and at the plant is 20 feet thick. The lower portion of this outcrop, which contains thick beds, is being crushed and used on the streets at Mt. Vernon. This stone is a hard, tough limestone, with a good cementing value. As a road material it ranks among the very best of southwestern Indiana, and is available in large quantities.

At the plant 100 cubic yards are crushed daily, and 25 men are employed. So far, most of the crushed stone has been floated down the river to Mt. Vernon, where it is used in building streets. For this work it is very well adapted and is showing splendid durability.

*For standard of comparison see p. 79.

Samples of stone from the quarry were tested at the Road Laboratory at Washington, with the following results:

*Results of Physical Tests of Carboniferous Limestone from the quarry of W. M. Williams, at West Franklin, Posey County.**

Specific gravity	2.7	French coefficient of wear	21.7
Weight per cu. ft. (lbs.)	168	Hardness	9.8
Water absorbed per cu. ft. (lbs.)	.82	Toughness	8
Per cent. of wear	1.8	Cementing value—Dry	43
		Wet	56

"A fairly hard and tough limestone with a very high resistance to wear which develops a good cementing value. Suitable for suburban and highway traffic. It has the highest coefficient of wear for limestone yet made."—Page.

VANDERBURGH COUNTY.

Area in square miles	236
Population in 1900	71,769
Miles of public roads	600
Miles of improved roads*	129.6
Percentage of roads improved	21.6
Miles improved with gravel	52.5
Miles improved with crushed stone	77.1
Average original cost of gravel roads per mile	$750
Average original cost of stone roads per mile	$1,000
Total original cost of improved roads	$116,475
Annual cost of repairs per mile on gravel roads 5 years old	$150
Annual cost of repairs per mile on stone roads 5 years old	$150
Satisfaction of farmers with investment in improved roads	Good
Authority	Harry Stinson, County Auditor

*"In 1880 there were in Vanderburgh County 72.45 miles of gravel and macadam roads, which were established as free turnpikes at that time. Since then there has been added 57.15 miles of roads that had originally been improved by the various township trustees and by resident freeholders, until there had been sufficient gravel or broken rock placed upon them to authorize the turnpike directors to include them as free turnpikes.

"There has been expended for repairs of free turnpikes since 1880 the sum of $482,265, making an average of $19,290 for each year."—H. S.

In the southwestern part of the State, separated from Kentucky by the Ohio River, is the county of Vanderburgh. It lies east of Posey, south of Gibson and west of Warrick counties. The surface rocks of this county are, for the most part, the Upper or Barren Coal Measures. The topography consists of the broad bot-

*For standard of comparison see p. 79.

toms of the Ohio and other streams, with intervening uplands, which are somewhat rolling.

The railway facilities are splendid. Diverging in all directions from Evansville are the E. & T. H., the E. & I., the Peoria Division of the Illinois Central, the St. Louis Division of the Southern, the Ohio Valley, the Louisville and Nashville and the St. Louis Division of the L. & N. In addition to these, the Evansville and Princeton traction line runs north from Evansville, almost bisecting the county, while another traction line is being built between Evansville and Mt. Vernon.

The roads of this county for the last 25 years have been built by repairing. The material for this repair work has been obtained from the limestone quarries at Milltown, from small limestone quarries of the county, where the stone is crushed by hand, and from the gravel bars of the Ohio River. Limestone outcrops, which have not been a source of supply but probably will be in the future, are found at numerous places in a ridge which extends southwest from the northeast corner of the county to Laubscher Mills, through the southeast corner of German Township, across Perry Township and on to West Franklin. At various points in the bluffs of Pigeon Creek outcrops a ferruginous limestone, which is too soft and impure for a road metal.

Gravel.

The only deposits of economic importance known are found in the old river bars of the Ohio. One of these is located on the J. Roth farm in the west central part of section 20 (7 S., 11 W.). The bed of gravel is one-half mile long, 300 yards wide and 1 foot deep. Below this depth it becomes sandy and then grades into a conglomerate. The material is of a very durable character, as is shown by its wear on a road which was built with it 23 years ago. This road is said to have never been repaired and is still in a good condition.

Limestone.

In the ridges, which enter Scott Township at the northeastern corner and extend southwest through sections 24, 23, 26, 27 and 34 (4 S., 10 W.), and sections 4, 9, 8, 7, 18, 19, 30 and 31 (5 S., 10 W.), are numerous outcrops of available limestone. This

VANDERBURG COUNTY.

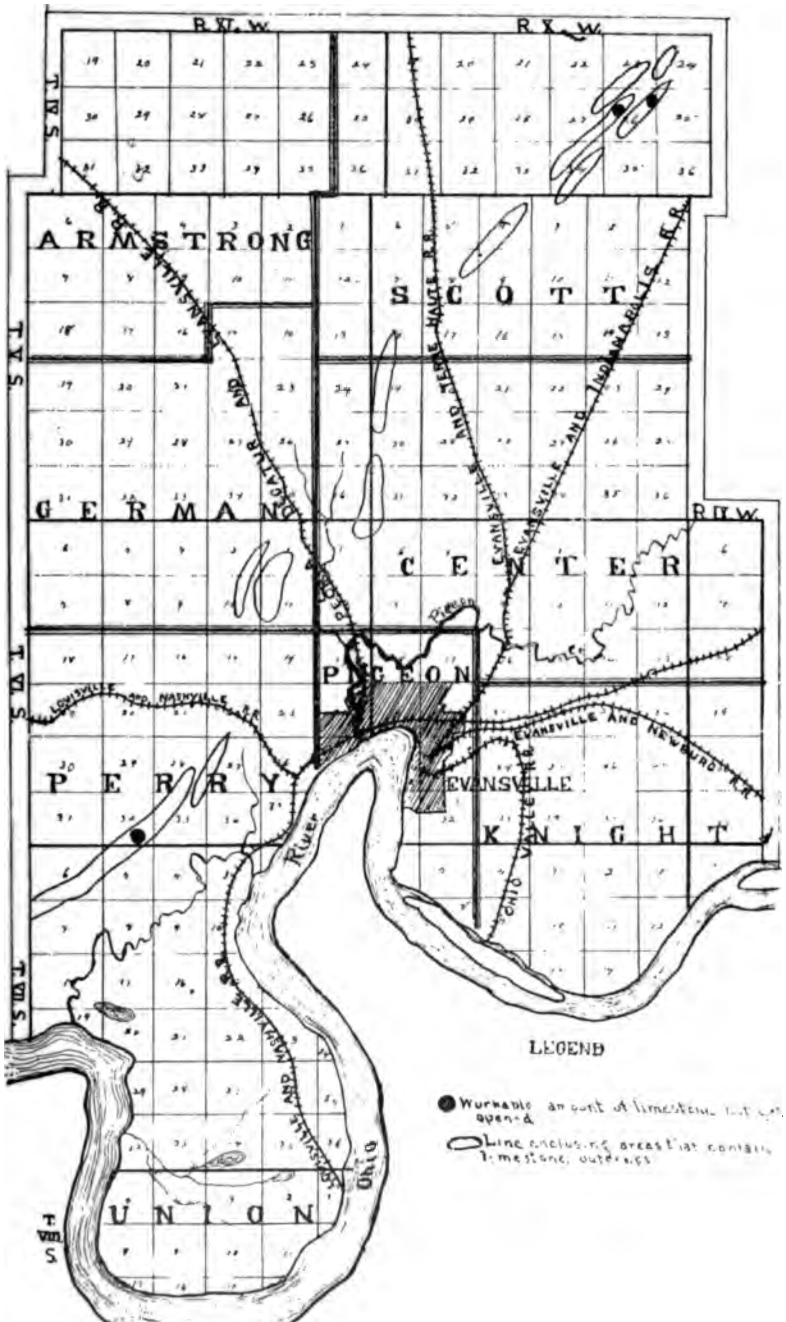


Fig. 58. Illustrating the distribution of road materials in Vanderburgh County.

stone was examined by the writer in the southwest quarter of section 4 (5 S., 10 W.), and found to be similar in physical character to the outcrop of this same ridge, which occurs on the W. Karnes place, in Posey County.

The Laubscher quarry, at Laubscher Mills, shows a section of 20 feet, the lower 9 feet of which are made up of a thick bedded, gray limestone, with medium hardness. Overlying these 9 feet are 9 feet of sandstone and 2 feet of soil.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*Results of Physical Tests of Coal Measure Limestone from the C. S. Laubscher quarry.**

Specific gravity.................	2.7	French coefficient of wear.	10
Weight per cu. ft..........(lbs.)	168	Hardness.................	11
Water absorbed per cu. ft..(lbs.)	1.38	Toughness................	8
Per cent. of wear..............	4	Cementing value—Dry....	17
		Wet....	52

"A rock of fair hardness, toughness and resistance to wear, which develops a good cementing value. Suitable for suburban and highway traffic."

A crushing plant, which is capable of an output of over 100 cubic yards per day, is located at the Laubscher Mills, but is not operated, because of the heavy stripping. This location is on the Evansville and Princeton interurban traction line.

This ridge, in which the Laubscher quarry is found, extends in a somewhat broken manner southwest through sections 1, 2, 3, 10, 11, 14, 15, 22, 27, 28, 33 and 32 (6 S., 11 W.), and sections 5, 6 and 7 (7 S., 11 W.). On the J. Kurn place of the southwest quarter of section 10 (6 S., 11 W.), some limestone has been taken out and pounded up for macadam. The section of the quarry shows two ledges of limestone, each of which is four feet thick. These are covered by 10 feet of sandstone, shale and soil. The upper ledge is of a gray color, with a reddish tinge, which is due to iron oxide. It has a medium hardness. The lower ledge is not so hard, but runs high in lime, which would give it a good cementing quality. The color is a bluish gray. The wearing quality of these stones, where they have been used in repairing the roads, is reported to be good.

*For standard of comparison see p. 79.

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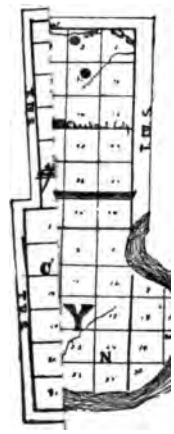
Weight per cu. ft..........(lbs.)	168	Hardness.................	11
Water absorbed per cu. ft..(lbs.)	1.38	Toughness................	8
Per cent. of wear..............	4	Cementing value—Dry....	17
		Wet....	52

"A rock of fair hardness, toughness and resistance to wear, which develops a good cementing value. Suitable for suburban and highway traffic."

A crushing plant, which is capable of an output of over 100 cubic yards per day, is located at the Laubscher Mills, but is not operated, because of the heavy stripping. This location is on the Evansville and Princeton interurban traction line.

This ridge, in which the Laubscher quarry is found, extends in a somewhat broken manner southwest through sections 1, 2, 3, 10, 11, 14, 15, 22, 27, 28, 33 and 32 (6 S., 11 W.), and sections 5, 6 and 7 (7 S., 11 W.). On the J. Kurn place of the southwest quarter of section 10 (6 S., 11 W.), some limestone has been taken out and pounded up for macadam. The section of the quarry shows two ledges of limestone, each of which is four feet thick. These are covered by 10 feet of sandstone, shale and soil. The upper ledge is of a gray color, with a reddish tinge, which is due to iron oxide. It has a medium hardness. The lower ledge is not so hard, but runs high in lime, which would give it a good cementing quality. The color is a bluish gray. The wearing quality of these stones, where they have been used in repairing the roads, is reported to be good.

*For standard of comparison see p. 79.



A very good exposure has been found in the bluff of a small valley on the property belonging to Henry Schutte, in the southwest quarter of section 32 (6 S., 11 W.). Here the limestone occurs in beds from 2 to 5 feet thick, has a gray color and a medium hardness. This stone has been broken by hand and used in repair work. It seems to show a fair durability.

A half mile northeast of the Schutte outcrop, in a bluff of the same valley, is an outcrop of limestone, which has a thickness of 30 feet. Without doubt a large quantity of stone is available in this vicinity.

WARRICK COUNTY.

Area in square miles	397
Population in 1900	22,329
Miles of public roads	750
Miles of improved roads	29
Percentage of roads improved	3.8
Miles improved with gravel	None
Miles improved with crushed stone	29
Average original cost per mile of stone roads	$1,785
Total original cost of improved roads	$51,760
First improved roads built	1899
Satisfaction of farmers with investment in improved roads	Good
Authority	R. D. O. Moore, County Auditor

With the Ohio River forming part of its southern border, and lying east of Vanderburgh, south of Pike and the southeastern corner of Gibson, and west and partly north of Spencer County, is the county of Warrick. The surface rocks of this entire county belong to the Coal Measures. The topography is rolling, some conspicuous ridges being found in the northwestern, north central and along the western edge of Pigeon Township.

The railway facilities of this county are poor. The Evansville branch of the Southern traverses the southern half from east to west, while the E. & T. cuts the northwestern corner. A suburban railway runs from Newburg to Evansville.

With exception of a few small bars of gravel and fine sand in the Ohio, the road material of this county is confined to the limestone. Outcrops of this, which are of economic importance, are found in a ridge near Millersburg, in sections 2, 4, 5, eastern 6, northern 8, western 3 and northwestern 1 (5 S., 9 W.), and 35,

36, southwestern half of 25, southeastern half of 26, southern parts of 32 and 33 (4 S., 9 W.). Another series of outcrops are found in a ridge near Lynnville, in the northeastern half of section 34, the southern part of 27, the southwestern corner of 26 and the northwestern corner of 35 (3 S., 8 W.). Both of these ridges tower very conspicuously above the adjacent regions. A small outcrop occurs in Pigeon Creek, 1½ miles west of Chandler.

The outcrops near Millersburg have been tested in the northwestern part of section 5 (5 S., 9 W.), by a large stone company, and are reported as being of a good quality for road building, and practically unlimited in amount. The E. & I. Ry. is within three-quarters of a mile of the place where the tests were made, and is connected to it by a valley with a gentle gradient.

At several places the writer examined the rock and found it to be a bluish gray, fine to medium-grained limestone, more or less streaked with iron oxide, and having a medium hardness. Under the stroke of the hammer it breaks in a heterogeneous manner, the streaks of iron oxide forming the plains of fracture. The durability of the rock as a road metal will undoubtedly be considerably affected by the ferruginous nature. Where this stone was used in building one-half a mile of road in the southwest quarter of section 19 (5 S., 9 W.), in the year 1881, the road is reported to still be in a fair condition, without having had any repair.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock, which was obtained from Louis Meyer's farm in the western part of this area, are given herewith as follows:

*Results of Physical Tests of Carboniferous Limestone from the Louis Meyer farm.**

Specific gravity	2.7	French coefficient of wear.	12.3
Weight per cu. ft. (lbs.)	168.4	Hardness	14
Water absorbed per cu. ft. (lbs.)	.97	Toughness	11
Per cent. of wear	3.3	Cementing value—Dry	15
		Wet	126

"A hard, tough rock with high resistance to wear and excellent cementing value. Suited for suburban and highway traffic."—Page.

By a comparison of the various tests of the Road Testing Laboratory of the United States, this rock is seen to be above the

*For standard of comparison see p. 79.

average for southwestern Indiana, and fully as good as the stone that is being shipped into the county.

Samples of this stone were analyzed by the U. S. Laboratory, with the following results:

Analysis of Carboniferous Limestone from the Louis Meyer farm.

	Per cent.
Alumina (Al_2O_3)	1.90
Iron oxide (Fe_2O_3)	0.50
Lime (CaO)	45.40
Magnesia (MgO)	Trace
Phosphoric acid (P_2O_5)	Trace
Insoluble in hydrochloric acid	15.32
Loss on ignition	36.93
Total	100.05

This rock is found outcropping more or less over an area extending northeast and southwest for about 5 miles and having a width ranging between ½ and 2 miles. With a portable crusher, which with the labor of 10 men would turn out from 40 to 50 cubic yards per day, stone could be crushed so as to supply 40 square miles in the northwest portion of the county, with little transportation.

The outcrop, north of Lynnville, is similar to that near Millersburg, in topographical position, quality and availability. It is a bluish, fine to medium-grained limestone, somewhat streaked with iron oxide. As seen from various exposures, it seems to cap the ridge and has a thickness of 35+ feet. Great blocks of this stone 20 feet across and 5 feet thick have broken off from the bedrock and are slowly sliding down the hillside.

The extent of this outcropping is at least one square mile, and probably much more. Since there is no railroad near by, and the roads are in need of improvement, a portable crusher would probably be a very practicable investment.

The outcrops found in the bed of Pigeon Creek, west of Chandler, are similar in physical character to those near Millersburg. The extent has not been determined.

Most of the 29 miles of improved road in this county were built six years ago, with the stone from Marengo. The depth of the macadam bed was made six inches flat and the width eight feet. In most places the macadam is put on to a depth of 14

inches at the center and 10 inches at the sides, and widths are from 9 to 10 feet. These roads of Warrick County would be in very fair condition if they were kept properly graded and ditched at the sides. The writer noticed where they were rutty, that often ditches had been allowed to clog up or the roadbed became sagged toward the center.

SPENCER COUNTY.

Area in square miles	406
Population in 1900	22,407
Miles of public roads	1,008
Miles of improved roads	29.5
Percentage of roads improved	2.9
Miles improved with gravel*	None
Miles improved with crushed stone	29.5
Average original cost of stone roads per mile	$2,000
Total original cost of improved roads	$58,510
Annual cost of repairs per mile on stone roads 4 years old	$25
First improved roads built	1901
Satisfaction of farmers with investment in improved roads—	Generally good
Authority	J. T. White, County Auditor

*About three and a half miles of streets in the town of Grandview are improved with gravel by working out the road tax.

This county, which is situated in the southwestern part of the State and is separated from Kentucky by the Ohio River, lies east of Warrick, south of Dubois and Warrick and west of Perry County. With exception of the Mansfield sandstone outcropping along Anderson Creek on the eastern border, the surface along the Ohio River and Pigeon Creek is bottom land, but advancing east it first becomes gently rolling, then more and more hilly until the eastern half is reached, where the surface is broken into high hills and sharp ridges, with narrow intervening valleys.

The transportation facilities are only fair. Of the St. Louis Division of the Southern, the Rockport branch passes from Lincoln City south to Rockport, and the Cannelton branch from Lincoln City through Maxville. The Evansville branch of the Southern Railway runs east and west from Pigeon Station to Rockport Junction.

This is one of the poorest counties of southwestern Indiana in

road metal. No gravel occurs, except some small bars of gravel and fine sand in the Ohio River. The limestone outcrops are found for one mile in the bluff of Sandy Creek, in the northern part of section 35, the southern part of section 26 and the southwestern portion of section 25 (6 S., 5 W.), and in the south bluff of Pigeon Creek, in the southeast corner of section 27 (4 S., 5 W.). A ferruginous argillaceous chert caps the top of a ridge in the northern halves of sections 27 and 28 (4 S., 5 W.).

The limestone outcropping in the bluff of Sandy Creek is a gray to dark gray rock with a fine to medium grain. Its hardness ranges between soft and medium. The beds vary from ½ to 1½ feet in thickness. Under the blow of a hammer the rock breaks irregularly, following to some extent numerous seams of iron oxide. The iron oxide is found in about the same proportion as that in the limestone of Warrick County. In addition to its extent of one mile along the bluff, it is seen by outcrops in tributary valleys to Sandy Creek that it extends back in the bluff at least a quarter of a mile. The thickness of the formation is 30+ feet, and the stripping is light along the bluff face, but rapidly increases as the stone extends back.

This outcrop is about 1½ miles from the Ohio River and is 9 or 10 miles from a railroad. The roads in this vicinity are all dirt. Because of these facts and the fair quality of this stone as a road-building metal, it would probably be the cheapest and most satisfactory source of supply to crush this stone with a portable stone crusher.

The rock occurring in the bluff of Pigeon Creek is a gray, calcareous limestone, with only a small amount of iron. It also is of a fair quality, but the stripping is rather heavy and the opening of a quarry would be rather expensive.

The ferruginous, argillaceous chert, which caps the ridge one-half mile north of the limestone outcrops, mentioned in the preceding paragraph, is harder than steel. This chert occurs in a bed 8+ feet thick and forms a small ledge where it meets the side slopes. It is said to outcrop in the sides of this ridge, more or less, for four miles. As a road metal it would be durable, but the crushing would be difficult, and it would not pack well on the road, because of no cementing material.

The 29.5 miles of improved road that are found in this county have been built with crushed limestone from Marengo and Milltown. These roads, where proper care has been given to ditching and grading, are smooth, durable and giving good satisfaction.

DUBOIS COUNTY.

Area in square miles	425
Population in 1900	20,357
Miles of public roads	700
Miles of improved roads	32
Percentage of roads improved	4.6
Miles improved with gravel	None
Miles improved with crushed stone	32
Average original cost of stone roads per mile	$3,062
Total original cost of improved roads	$98,225
Annual cost of repairs per mile on stone roads 5 years old	$35
Miles of improved roads (stone) built in 1905	10
First improved roads built	1903
Satisfaction of farmers with investment in improved roads	Good
Authority	M. A. Sweeney, County Auditor

Dubois County, which is found in the southwestern part of the State, is bounded on the north by Daviess and Martin, on the east by Orange, Crawford and Perry, on the south by Perry, Spencer and Warrick, and on the west by Warrick and Pike counties. The rocks of three geological epochs are found in this county, viz., the Huron limestones and sandstones of the Lower Carboniferous and the Mansfield sandstone and Coal Measures of the Carboniferous Periods. The rocks of the Huron group occur only in small isolated areas along Patoka River and its tributaries in the northeastern part of the county and along Anderson Creek in the southeastern corner. The Mansfield sandstone covers the greater part of the eastern third, and the Coal Measures most of the western two-thirds. The topography of the county is considerably broken. Hills from 75 to 200 feet are numerous in the northeastern part, and from 50 to 150 feet south and west of Huntingburg. The northwestern part is more level.

The railway facilities are poor. The St. Louis Division of the Southern crosses the county from east to west a little south of the center. From Huntingburg, a branch of this road extends north to Jasper and another south to Lincoln City.

For road materials this is one of the poorest counties of southwestern Indiana. No gravel is found in it, and the limestone only occurs in the northeast and southeast corners, and seven miles southwest of Jasper in the bluff of Patoka River in sections 7 and 18 (2 S., 5 W.). The limestone of the northeast corner of the county occurs in ridges and in stream bluffs. In a ridge one-half mile east of Ellsworth is a soft, coarse-grained limestone, with a fair degree of toughness and a buff color. For a quarter of a mile along this ridge it is found within a few feet of the surface

DUBOIS COUNTY.

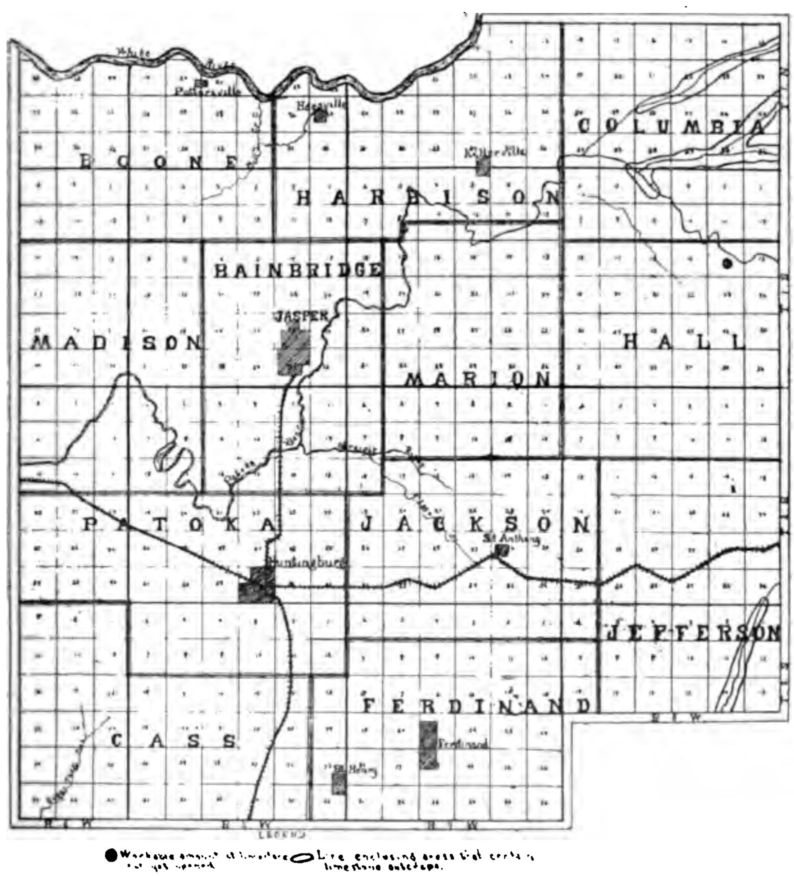


Fig. 59. Illustrating the distribution of road materials in Dubois County.

in large quantities. Abundance of this stone is available in the eastern half of the civil township of Columbia.

The stone in the southeastern corner varies between a coarse and fine-grained limestone, and is said to be of a fair quality.

The limestone that occurs seven miles southwest of Jasper in the bluff of Patoka River is a soft, bluish gray, coarse-grained rock, which is from 50 to 70 feet above the stream bed. It is from four to six feet thick and is found more or less along the river for three-quarters of a mile. This stone is high in lime, and is closely associated with a black, argillaceous limestone, which would be almost useless as a road metal. The stripping ranges between 0 and 10 feet.

PERRY COUNTY.

Area in square miles	383
Population in 1900	18,778
Miles of public roads	800
Miles of improved roads	None
Percentage of roads improved	....
Authority	A. P. Fenn, County Auditor

A little west of the south central part of Indiana, and bordering on the Ohio River, is the county of Perry. The rocks of three geological epochs form its surface, viz., the Coal Measure and Mansfield sandstone of the Carboniferous and the Huron limestone and sandstone of the Lower Carboniferous periods. The rocks of the Huron group make up the surface of the greater part of the eastern half and are exposed in the valleys of the western half. The surface rocks of the western half are about equally divided between the Coal Measures and Mansfield sandstone. The surface of this county is very broken, the hill summits being from 250 to 400 feet above the valleys of the larger streams. The only level country is found in the stream bottoms.

Although this county has only a quarter of a mile of improved road, which was built by private donations, it ranks above the average of southwestern Indiana in road materials. Numerous outcrops of the Huron limestone occur in the stream channels and bluffs of the eastern half of the county, while a few scattered exposures of the Coal Measure limestone are found in the western half. On the bluffs of the Ohio River above Cannelton and Tell

City are some very fair gravel deposits. Gravel is also obtained from river bars of the Ohio.

Gravel.

The gravel occurring in the bluff above Cannelton and Tell City is beneath 11 feet of stripping and has a depth of 15+ feet. Tests have not been made to determine the extents. The sizes of the material are 45 per cent. clay, 1 per cent. fine medium sand, 2 per cent. medium sand, 4 per cent. coarse sand, 25 per cent. roofing pebble, 21 per cent. gravel and 2 per cent. boulder. The rock percentages are 74 ferruginous argillaceous chert, 4 ferruginous argillite, 2 ferruginous sandy argillite, 8 limestone, 10 quartz and 2 shale. This material, as a whole, is very hard, but considerably weathered. Its wearing quality has not been well tested, but seems to be fair for a gravel.

The gravel found in the river bars that occur at several places both north and south of Cannelton is mingled with a large amount of fine sand, which will have to be screened. The rock percentages of this gravel, taken from the average of three samples, are 31 granite, diorite and andesite, 26 limestone, 16 ferruginous argillaceous chert, 9 quartzite, 6 quartz, 5 ferruginous argillite, 4 shale and 3 sandstone. For road use this material will be less durable than the crushed limestone, and will be very slow in packing, because of the absence of clay.

Limestone.

Of the numerous outcrops of the Huron limestone in the eastern half of the county, the writer visited some in the bed of Millstone Creek, in sections 9, 16 and 17 (7 S., 2 W.), in the bluff of Little Blue River, in section 2, and in the bluff of a tributary to Little Blue River, in the northeast quarter of section 11 (4 S., 1 W.). Many other outcrops of a similar nature are reported between these two points in either the stream beds of the bluffs of almost all intervening tributaries of the Ohio River.

This stone ranges between a gray limestone with a coarse grain to a blue, compact limestone with a fine grain. Considerable of the stone in Millstone Creek is a fine-grained rock with phenocrysts of calcite, some of which are 40 millimeters across. This

rock contains scarcely any iron and seems to have a fair degree of hardness and toughness. It would probably be suitable for local use, and since there are no railroads in the eastern half of the county, a portable crusher would be likely to give the best satisfaction.

The Coal Measure limestone outcropping in the bluffs of Deer Creek, in section 6 (7 S., 2 W.), and section 31 (6 S., 2 W.), is ferruginous and softer than the Huron rock.

CRAWFORD COUNTY.

Area in square miles	304
Population in 1900	13,476
Miles of public roads	229
Miles of improved roads	$7\frac{7}{8}$
Percentage of roads improved	3.4
Miles improved with gravel	None
Miles improved with crushed stone	$7\frac{7}{8}$
Average original cost of stone roads per mile	$1,731
Total original cost of improved roads	$14,110
Miles of improved roads (stone) built in 1905	$6\frac{7}{8}$
Miles of improved roads (stone) contracted for 1906	15
First improved roads built	1892
Miles of improved road built since 1895	$6\frac{7}{8}$
Satisfaction of farmers with investment in improved roads	Not stated
Authority	S. E. McFall, County Auditor

Crawford County is found in the south central part of Indiana, bordering on the Ohio River. It lies east of Perry and Dubois, south of Orange and Washington, west of Harrison and north of Perry County. The surface rocks of this county are the Huron group and the Mansfield sandstone, the latter being confined to the western third. Rocks of the Coal Measure occur in the high hills in the vicinity of Taswell and Eckerty, and the Mitchell limestone is found in the eastern part. The surface of this county is very broken, hills near the Ohio and Blue Rivers ranging from 250 to 480 feet in elevation.

The only railroad in this county is the St. Louis Division of the Southern, which crosses the northern third from east to west.

For road material this is the best county of this southwestern Indiana area. Limestone outcrops in almost all parts of it, but that of the best quality is confined to the eastern half.

On a hillside, 1½ miles east of Wickliffe, in the southwest quarter of section 3 (2 S., 2 W.), is an outcrop of a dark grayish limestone, with a fine to medium-grain and a rather low degree of hardness. It is available in workable quantities, and is located in a vicinity where the roads have not been improved.

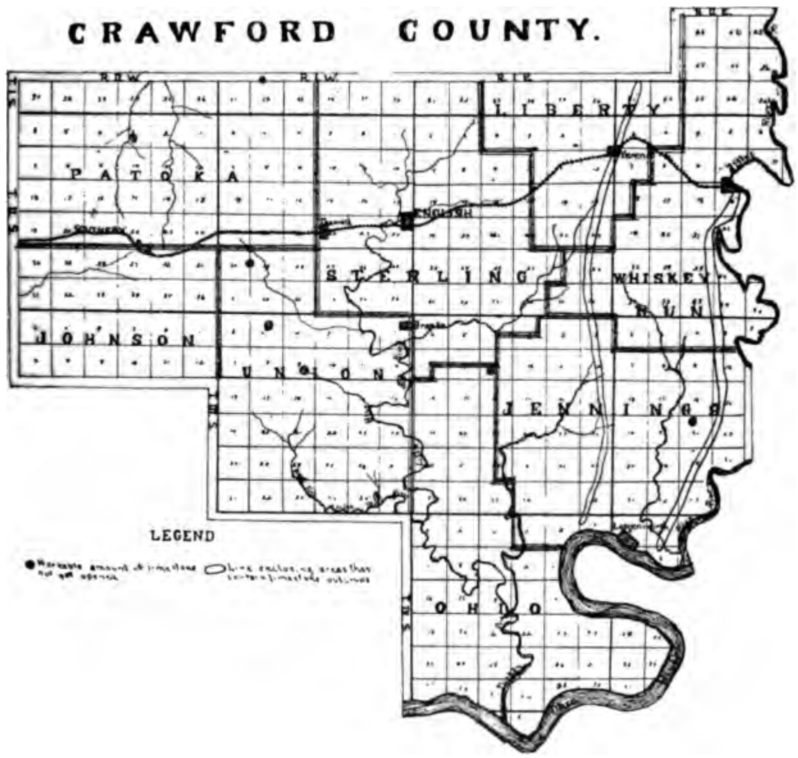


Fig. 60. Illustrating the distribution of road materials in Crawford County.

The rock coming to the surface in a small stream bed in the northeast corner of English has a dark gray color and a medium hardness. In grain it ranges from a fine and compact to a medium. Large quantities are apparently available. The stone found in the hills 1½ miles northwest of English is rather ferruginous and would make an inferior road material.

A tough, medium-grained stone, with a gray color and average hardness, is found 2½ miles southeast of English along the English-Magnolia road. Along this same road, 2½ miles northwest

of Magnolia, outcrops in a hillside a dense, fine-grained limestone, with a bluish gray color. It has a medium hardness and toughness and occurs in large quantities. Since there are no railroads in this vicinity, a portable crusher might be used to advantage for the local supply.

Two and one-half miles south of Grants, in the bluffs of Little Blue River, are numerous outcrops of a coarse-grained and rather ferruginous limestone, with a medium hardness and fair degree of toughness. These alternate with beds of sandstone, and show in places a thickness of 15+ feet. Where they run low in iron oxide, they might serve for local use.

A similar stone to the one mentioned in the above paragraph, interstratified with a bluish gray, fine-grained and dense limestone, with a medium hardness, occurs in the bluffs near Sulphur Well. Large quantities of this stone are available.

The entire region between Leavenworth, Wyandotte Cave, Marengo and Milltown contains numerous outcrops of the light bluish gray, compact and very fine-grained stone that is being shipped, on a large scale, from the quarries of the two latter towns. The rock, generally, is almost free from iron oxide and contains phenocrysts of calcite that are very noticeable to the naked eye. Another rock of this area which outcrops to a much less extent is a gray, coarse-grained rock with a fair degree of hardness and toughness.

The largest quarry of this southwestern area is found at Milltown. The quarry wall is 300 yards long and 100 feet high. In this 100 feet, 49 are used as road material. Thirty-five feet of these are a fine-grained, compact, hard and brittle limestone, with a light, bluish gray color. This is the rock that composes the main macadam for this southwestern area. Eight feet are composed of a yellow, medium-grained stone, which is somewhat tougher and softer than the light blue. Six feet are a gray, very coarse-grained limestone, with a fair degree of hardness and toughness. In addition to this rock, which is used for macadam, are 26 feet that are used in making lime. Samples of macadam stone were tested in the road laboratory at Washington, the results of the tests being as follows:

*Results of Physical Tests of Mitchell Limestone from Speed's quarry at Milltown, Crawford County.**

Specific gravity	2.66	French coefficient of wear	11.6
Weight per cu. ft. (lbs.)	165.3	Hardness	10
Water absorbed per cu. ft. (lbs.)	.46	Toughness	8
Per cent. of wear	3.4	Cementing value—Dry	18
		Wet	95

"A hard and fairly tough rock with an average resistance to wear and excellent cementing value. A good all-around road material."—Page.

Samples of the stone were analyzed at the same laboratory, and their percentage composition found to be as follows:

Results of Chemical Analysis of Mitchell Limestone from Speed's Quarry at Milltown, Crawford County.

	Per cent.
Alumina (Al_2O_3)	0.11
Iron oxide (Fe_2O_3)	0.24
Lime (CaO)	52.10
Magnesia (MgO)	2.48
Insoluble in hydrochloric acid	1.82
Loss on ignition	43.45
Total	100.20

At this quarry the stone crusher, which is the Gates No. 7½, crushes on an average of 650 cubic yards daily. To operate the lime kilns and the crushing plant 150 men are employed at an average wage of $1.62 per day.

Next in importance and output to the Milltown quarry is that at Marengo, where we find a section showing 40 feet of the fine-grained, compact. hard and brittle limestone, with the light bluish gray color; 6 feet of the yellow, medium-grained rock, and 4 feet of the gray and coarse-grained limestone that are found in the Milltown quarry. The main quarry wall is 150 feet wide and 74 feet high. The side walls are 80 feet long, and from a few feet to 74 feet high.

The results of the tests of the U. S. Road Testing Laboratory on a sample of this rock are given herewith as follows:

*For standard of comparison see p. 79.

*Results of Physical Tests of Mitchell Limestone from the Marengo Manufacturing Company's quarry.**

Specific gravity	2.65	French coefficient of wear	10.8
Weight per cu. ft. (lbs.)	165	Hardness	8.9
Water absorbed per cu. ft. (lbs.)	1.61	Toughness	9
Per cent. of wear	3.7	Cementing value—Dry	16
		Wet	53

"A rock of average hardness, toughness and resistance to wear which develops a good cementing value. Suitable for suburban and highway traffic."

The Gates No. 5 is the stone crusher used at this quarry, and the daily output is 350 cubic yards. Thirty-five men at an average wage of $1.62 per day are employed at this quarry.

*For standard of comparison see p. 79.

SECTION XV.

THE ROAD LAWS OF INDIANA. IN FORCE JANUARY 1, 1906.

LOCATION, VACATION AND CHANGE.

HIGHWAYS—PETITION AND NOTICE.

SECTION 1. Be it enacted by the general assembly of the State of Indiana, That whenever twelve freeholders of any county, six of whom shall reside in the immediate neighborhood of a highway proposed to be located, vacated, or a change therein made, shall petition the board of commissioners of such county for the location, vacation or change thereof, such board, if satisfied that notice of such application has been given by publication once each week for two weeks successively in a newspaper published in the county, or by posting up notices in three of the most public places in the neighborhood of such highway, at least twenty days before the meeting of the board at which such petition is to be presented, and by the county auditor mailing a copy of such notice to the postoffice address of each land owner affected by said proceeding at the time of posting, providing such postoffice address can be ascertained by inquiry at the office of the county treasurer, shall appoint three disinterested freeholders of the county to view such highway.

DUTIES OF VIEWERS.

SEC. 2. The auditor of such county shall issue a percept to the sheriff thereof, commanding him to notify such viewers of the time, place and object of their meeting. Such viewers, at such time, after having taken an oath, before some officer authorized to administer the same, faithfully to perform their duties, shall proceed to view the highway to be located, or vacated or the change to be made; and if they shall deem such location, vacation or change to be of public utility, they shall, in case of a new highway or a change in an old one, proceed to lay out and mark the same on the best ground, not running through any person's enclosure of one year's standing without the owner's consent, unless, upon examination, a good way can not otherwise be had without departing essentially from the route petitioned for: Provided, That where the road is laid out upon the line dividing the lands of two persons, it shall be laid one-half on each side of such line: And provided further, That whenever the location of a highway is petitioned for upon and along any line which forms also the boundary of any city or town, the board of commissioners shall, for the purpose of locating such highway, have jurisdiction over the lands and lots lying within such corporate limits, and immediately affected by such proceedings and location; and the owners of such lands and lots so affected, shall have the same rights and remedies in the matter of the

location, vacation or change of such highway as the owners of the lands lying on the opposite side thereof, and outside of such city or town.

REPORT OF VIEWERS—PROCEEDINGS.

SEC. 3. Such viewers, or a majority of them, shall make a report of their proceedings at the ensuing session of the board of commissioners, giving a full description of such location, change or vacation, by routes [metes] and bounds, and by its course, distance and width, except that in case of the vacation of a road, or any part thereof, such description only as will designate it clearly shall be required; and, in such case, a copy of the order vacating such highway shall be transmitted by the proper auditor to the trustee of the township or trustees of the townships in which such vacated highway is situated, who shall cause the supervisor or supervisors thereof to be notified accordingly.

NO OBJECTION—ORDER AND NOTICE.

SEC. 4. If no objection be made to such proposed highway, vacation or change, such board shall cause a record thereof to be made, and, in case of such location or change, shall order the highway to be opened, and kept in repair, which order shall be transmitted to the trustee of the township or trustees of the townships in which such location or change is made; and such trustee or trustees shall cause a copy of such order to be entered at length on the township's record book or books, and notice thereof to be given to the proper supervisor or supervisors to work such highway as so located or changed.

REMONSTRANCE FOR DAMAGES—REVIEWERS.

SEC. 5. If any person through whose land such highway or change may pass shall feel aggrieved by reason of such location, vacation or change, such person may, at any time before final action of the board thereon, set forth such grievances by way of remonstrance under oath, stating therein that he is damaged thereby in a sum mentioned; and the said board shall thereupon appoint three disinterested freeholders of the county as reviewers, and assign a day and place for them to meet.

REVIEWERS—OATH AND DUTIES.

SEC. 6. Such reviewers shall meet at the time and place designated, and take an oath faithfully to discharge the duties assigned them, and shall then, or on any other day to which a majority may adjourn, prior to the next session of such board, proceed to review the proposed highway and assess the damages, if any, which such remonstrator may sustain from such highway being opened, vacated or changed through his lands, and shall report the same to the ensuing session of such board.

REVIEWERS' REPORT—ACTION.

SEC. 7. If a majority of the reviewers assess and report damages in favor of the remonstrator, and the board shall consider the proposed highway, vacation or change to be of sufficient importance to the public,

it shall order the costs and damages to be paid out of the county treasury; otherwise such costs and damages shall be paid by the petitioners or others interested. If a majority report against the claim for damages the remonstrator shall pay the costs. When payment of damages is made as herein provided, such highway shall be recorded and ordered to be opened and kept in repair, as hereinbefore provided, after notice to the proper trustees.

ANOTHER REVIEW.

SEC. 8. If it shall be made to appear to the board that the damages assessed are unreasonable, it may set aside such assessment and order another review, under the same regulations as provided in case of the first review.

NEW VIEWERS—UTILITY AND DAMAGES—DUTIES.

SEC. 9. If any freeholder of, and residing in, such county shall remonstrate against the proposed highway at any time before final action thereon, as not being of public utility, other reviewers may be appointed, who shall, after having taken an oath faithfully to discharge the duties assigned them, meet at the time and place designated and then, or on a day to be by them fixed, proceed to examine the proposed highway, and shall make report to such board at its next session, whether, in their opinion, the said highway, vacation or change will be of public utility: Provided, however, That a remonstrance for want of public utility and for damages may be filed at the same time, and may be referred to the same reviewers, who shall then be required to report both as to public utility and as to damages.

ACTION ON REPORT.

SEC. 10. If a majority of the reviewers last named report against the public utility of such highway, vacation or change, the petition shall be dismissed; but if they report favorably thereto, the remonstrator shall pay the cost of the review, and, in case of a location or change, the highway shall be recorded and ordered to be opened and kept in repair: Provided, however, That an appeal shall lie to the circuit court from any such order dismissing such petition or ordering such highway established, as provided in section one hundred and two of this act.

DAMAGES—PAYMENT.

SEC. 11. No such highway shall be opened, worked or used, until the damages assessed therefor shall be paid to the persons entitled thereto, or deposited in the county treasury for their use, or until such persons shall give their consent thereto in writing, filed with the auditor of such county.

COSTS—BOND.

SEC. 12. Whenever any petition for the location, vacation or change of any public highway has been presented to the board of commissioners of any county in this State, and such board shall have appointed viewers for the same, and such viewers shall have reported that they deem the proposed location, vacation or change of such highway of no public utility, then no second or subsequent petition for the location, vacation or change

of such highway shall be acted upon by the commissioners, unless the petitioners shall first file with the county auditor a bond with surety to be approved by him, conditioned that such petitioners will pay all costs in the case if the viewers to be appointed to view such proposed location, vacation or change of such highway, shall report that they deem the same to be of no public utility.

WHO CAN NOT BE VIEWERS.

SEC. 13. No person owning lands, or who is related by consanguinity, within the sixth degree, to any person owning lands, along any highway proposed to be opened, vacated or changed shall be competent to act as viewer, or reviewer thereof.

FENCES—REMOVAL NOTICE.

SEC. 14. Whenever any public highway shall have been laid out through any enclosed land, the supervisor shall give the occupant of such land, or the owner, if a resident of the road district, sixty days' notice in writing, to remove his fences; but such owner or occupant shall not be compelled to remove any such fence between the first day of April and the first day of November; and if such fence is not removed pursuant to such notice, such supervisor shall cause the same to be done at such owner's expense, which may be recovered in an action by the supervisor, in the name of the township trustee, before any justice of the peace in the county, and, in case of recovery, the judgment shall also include costs and attorney's fees.

HIGHWAYS BY USE—WIDTH—RECORDING.

SEC. 15. All highways heretofore laid out acording to law, or used as such for twenty years or more, shall continue as located and as of their original width, respectively, until changed according to law; and hereafter no highway shall be laid out less than thirty feet wide, and the order for the laying out of the same shall specify the width thereof. The board of commissioners shall have power to cause such of the roads used as highways as shall have been laid out, but not sufficiently described, and such as have been used for twenty years, but not recorded, to be ascertained, described and entered of record. Such action of the board shall be on petition filed by one or more resident freeholders of the county, of which petition notice shall be given by posting in three public places along the line of such road twenty days before the session at which such petition shall be considered. And such board shall declare and establish the width of any such highway, which width shall not be less than thirty feet; and where any such highway shall be located upon a line dividing the lands of different owners one-half thereof shall be taken from the land of each owner.

NON-USER OF HIGHWAY.

SEC. 16. Every public highway already laid out, or which may hereafter be laid out, and which shall not be opened and used within six years from the time of its being so laid out, shall cease to be a highway for any

purpose whatever; but if any distinct part thereof shall have been opened and used within six years, such part shall not be affected by the provisions of this section, nor shall this section be applied to streets and alleys in any city or town.

PETITION TO CHANGE LOCATION—NOTICE.

SEC. 17. Any person through whose land any highway heretofore located and established, or hereafter to be located and established, may run, may petition the board of commissioners of the proper county for permission to change the location of such highway on his land, or on the lands of any other person consenting thereto. Every such petitioner shall give notice of his intention to file such petition, by posting written or printed notices thereof, in three or more public places in the vicinity of such proposed change, for twenty days before the first day of the term of the board at which such petition is to be presented.

VIEWERS ON RELOCATING—DUTIES.

SEC. 18. Upon the filing of such petition, and proof of notice as provided for in the preceding section, the board of commissioners shall appoint three disinterested freeholders of the county as viewers, who shall meet at such time as the board may appoint, and, after having been duly sworn, or affirmed, shall then, or on any other day to which the majority may adjourn prior to the next session of such board, proceed to view the premises; and they, or a majority of them, shall report the respective lengths of the established and proposed highway, and the situation of the ground along each, and whether, in their opinion, the public would be materially injured by such proposed change, and shall file their report with the board of commissioners at its next session thereafter.

REPORT—REMONSTRANCE—PROCEEDINGS—COSTS.

SEC. 19. Upon the filing of such report, and before action thereon, if the report be favorable to such change, any freeholder may file his remonstrance against the same, stating therein the reasons why such change ought not to be made, and an issue may be made thereon; and if the report of the viewers be unfavorable to such change, the petitioner may make an issue thereon, and any such issue shall be tried before the board of commissioners, as other issues of fact are tried; and if, upon the report of the viewers, or upon any issue tried as above, the board shall be of opinion that the public will not be materially injured by such proposed change, it shall make an order granting permission to the petitioner to make such change, and upon satisfactory proof, then or thereafter, that the new road has been opened and improved, and made equally convenient for travelers, the board shall make an order vacating so much of the former highway as lies between the different points of intersection. All the costs of such proceeding shall be paid by the petitioner: Provided, That when a remonstrance is filed, and the issue found against the remonstrant, he shall pay all the costs occasioned by such remonstrance.

COMPENSATION—VIEWERS—SURVEYORS.

SEC. 20. Viewers and reviewers, for each day engaged in viewing or reviewing a highway by order of any board of commissioners, shall receive two dollars. Surveyors, for their services in locating highways, will receive two dollars and fifty cents a day, and five cents for each mile necessarily traveled; and for making out a complete report of survey of such highway, one dollar, and, in case the survey exceed five miles, two dollars. Chainmen and axmen employed in such surveys will each receive one dollar and fifty cents a day.

TWO OR MORE COUNTIES—PETITION—PROCEEDINGS, ETC.

SEC. 21. In case of the proposed location, vacation or change of a public highway, extending into two or more counties, jurisdiction as to all the proceedings shall be in the board of commissioners of the county before whom the petition is first filed; and such proceedings shall be the same as those hereinbefore provided for in case of the location, vacation or change of a public highway in one county, so far as the latter are applicable—except that the petition shall be signed by not less than twenty-four freeholders of one or more of the counties into which such highway proposed to be located, vacated or a change therein made, is to extend, six of whom shall reside in the immediate neighborhood of the proposed highway, and not less than three of whom shall reside in each of such counties; except, also, that each set of viewers or reviewers to be appointed shall be equal in number to the number of the counties to be affected, and one of whom shall be appointed from each of such counties; and in case the number of such viewers or reviewers shall be even, and they can not agree, the viewers or reviewers so appointed shall select another who shall perform the same duties and receive the same fees as the viewers or reviewers first appointed. Costs and damages shall be paid as in case of proceedings for the location, vacation or change in a highway in one county; but the county having jurisdiction of the proceedings shall be entitled to recover from each of the other counties a proportionate amount of the expenses paid out of its treasury according to the proportion of the length of such highway in each of such other counties, to be recovered as any claim due from one county to another. Whenever any such highway is located, vacated or changed, a certified copy of the order therefor shall be transmitted by the auditor of the county having jurisdiction of the proceedings to the auditor of each of the other counties and entered of record in the order book of the board of commissioners of each of such counties, and a copy of the order shall be transmitted to the proper township trustees, as in case of a highway located, vacated or changed in one county.

ON COUNTY LINES—WORKING—PROCEEDINGS, ETC.

SEC. 22. Whenever twelve freeholders of any county shall present to the board of commissioners a petition setting forth that a public highway, describing it, in their road district or districts, township or townships, is situated upon or near a county line, and has not been worked for a time to be stated, in consequence of a difference of opinion as to

whose duty it was to work such highway, such board shall appoint as viewers two freeholders of the county, not belonging to the road district where such highway is required to be worked, who shall employ the county surveyor to perform the duties required by this section. The auditor of such county shall immediately, through the auditor of the other county, give notice to the commissioners of the county upon whose border such highway is situated of the filing of such petition, sending a copy of the same, and also of the appointment of such viewers; whereupon it shall be the duty of the county board thus notified to appoint two other viewers of like qualifications, and the four persons so appointed, with such county surveyor, shall meet at the time and place designated by such first board of county commissioners, and, having first been sworn according to law, shall proceed carefully to examine the condition of such highway, and, if practicable, shall locate the same upon the county line, one-half in each county. Such viewers shall make out a report of their proceedings, describing such highway by metes and bounds and showing its beginning, termination and width. One copy of such report shall be transmitted to the board of commissioners of each county, and recorded as in case of other highways, and the proper township trustees shall each be furnished with a certified copy of the same. It is made the duty of such trustees to open and improve such highway as required by law. The said county surveyor is authorized to act with such four viewers in locating such highway; and whenever the board of commissioners of either county shall fail, refuse or neglect to appoint viewers to act upon any petition filed according to the provision of this section, the two viewers appointed by the other county, in connection with the county surveyor, shall proceed to discharge all the duties required of the four viewers, and their action in the premises shall have the same force and effect, and be equally binding, as the action of the four viewers.

ON STATE LINES—IMPROVEMENTS—PROCEEDINGS, ETC.

SEC. 23. Whenever it may be desirable to lay out, construct or improve, by straightening, grading, draining, paving, graveling or macadamizing, any highway or any part thereof, lying on, along or near to the State line between the State of Indiana and any adjoining State, the boards of commissioners of the several counties of this State so adjoining another State shall have authority to join with the county commissioners or other proper authorities of the adjoining counties of such other State in the construction and improvement in the manner aforesaid of such highways; and such boards of commissioners are hereby authorized jointly to enter into contracts with the proper authorities in such adjoining State, for the construction and improvement of such highways. Each county shall pay such proportion of the cost of such improvement as shall be determined by and between the said board of commissioners of this State and the proper authorities of such adjoining State to be equitable and just. Such improvement shall be made by the boards of commissioners on petition by the land owners, pursuant to the laws now or hereafter in force in this State, and this section is supplemental to all the provisions of this act for the construction and improvement of highways, so far as the same

can be made applicable. Any highway so constructed or improved under this section shall be free of toll and shall be perpetually kept in repair by the provisions of this act for the repair of highways; the said adjoining county or counties contributing proportionately in keeping the same in repair according to the proportions paid for the original cost thereof.

STREAMS AND WATER-COURSES.

STREAM DECLARED NAVIGABLE—PETITION.

SEC. 24. The boards of commissioners in the several counties in this State are authorized to declare any stream or water-course in their respective counties navigable, on the petition of twenty-four freeholders of the county, residing in the vicinity of the stream which it is intended to be declared navigable.

EXAMINATION OF STREAM.

SEC. 25. On the filing of the petition provided for in the last section, any such board shall cause an examination of the stream or water-course intended to be declared navigable to be made by some suitable person, who shall ascertain and report to the board the length of the same, and how much thereof is capable of being declared navigable, which report such board shall confirm if satisfied that the stream, if navigable, would be of public utility; and thereupon such board shall declare such stream navigable and cause the report to be recorded on the records of the board, as public highways are recorded.

REMOVAL OF OBSTRUCTIONS.

SEC. 26. The supervisor of the road district through which such stream or water-course, or any part thereof, may run, shall take charge thereof as a part of his general duties as supervisor of public highways; and for the purpose of keeping the same in a navigable condition he may annually call out for two days the inhabitants of such district, liable to work on the public highways, who shall work on such stream and clear out timber and other obstructions that may interfere with the navigation thereof.

PENALTY FOR OBSTRUCTING.

SEC. 27. Any person obstructing any stream or water-course declared navigable shall be liable to the same pains and penalties as persons guilty of obstructing public highways; and the general laws governing public highways, and the laying out and working thereof in all other respects, shall, so far as applicable, govern in the defining and working of navigable water-courses.

PIERS, WHARVES, ETC.

SEC. 28. Any riparian owner of lands within this State bordering upon a navigable stream may build and maintain within his premises so bordering on such stream, and upon the submerged lands beneath the water thereof, piers, wharves, docks or harbors in aid of navigation and

commerce, and may use, occupy and enjoy the same as appurtenant to his said lands: Provided, That such piers, docks and wharves shall not extend into such stream further than is necessary to accommodate shipping and navigation, and in no case so as to obstruct the same.

NOT TO AFFECT MILLS, ETC.

SEC. 29. The declaration of water-courses as navigable by county boards shall not affect any mill, dam, aqueduct, viaduct, bridge or machinery on any such stream, except in cases where the same have been abandoned for a period of twelve months.

FUND TO REMOVE OBSTRUCTIONS.

SEC. 30. The boards of commissioners of the several counties shall have power to use such sums as may be appropriated from the county treasury, and as they may deem necessary, to remove obstructions from streams that have been heretofore or may be hereafter declared navigable according to law.

CAVING—NOTICE—FENCE REMOVAL.

SEC. 31. When any public highway, running or passing along the bank of any water-course, shall, by the falling or washing away of the bank of such water-course, become unsafe or inconvenient for use as a public highway, it shall be the duty of the supervisor having such highway in charge forthwith to give the owner or occupant of the land over which such highway passes, notice to remove his fence back from the bank of such water-course far enough to admit of the opening and construction of a road at least forty feet wide; and if the owner or occupant of such land should neglect to remove such fence, as required by such notice, it shall be the duty of such supervisor to call out the hands liable to work on highways in his road district, and forthwith to remove such fence, doing to the owner or occupant no greater damages than is necessary for the removal of the fence. If any dwelling or building should stand so near such water-course that a sufficient space is not left for such road, then such supervisor may open such highway in the rear of such dwelling house or other building.

DAMAGES—VIEWERS.

SEC. 32. When such fence shall be removed, or road changed to the rear of buildings, as provided for in the preceding section, the owner of such land may file with the board of commissioners of the county where the same is situated a claim for damages for the removing of such fence or the change of such road, and for the use of the ground over which the said road shall pass; and upon the filing of such claim, it shall be the duty of such board of commissioners to appoint two reputable freeholders of such county to view such premises and assess the damages of such claimant, by reason of the appropriation of his said land for such highway and the removal of such fence.

OATH—REPORT—REVIEWERS—PAYMENT.

SEC. 33. The viewers appointed as provided for in the last section shall be sworn faithfully and impartially, and upon actual view of such premises, to assess such damages and report the same to such board of commissioners, and such board may allow and order the same to be paid out of the treasury of such county; or if the board deem such assessment to be too high it may appoint reviewers to make another assessment, who shall be sworn, and proceed in like manner to assess such damages, and report the same to such board, and such board shall order the amount of the assessment to be paid out of the treasury of the county. If such claimant shall feel aggrieved by such assessment, he may demand a review of such premises, and a new assessment of such damages, whereupon such board shall appoint reviewers, as aforesaid, who shall review such premises, and re-assess such damages; but if such last-named reassessment shall be for no greater sum than the first assessment, such claimant shall pay the cost of such last named review.

GATES AT RIVER BANK.

SEC. 34. Persons living on or owning property along any water-course that is navigable for boats of a large size, are hereby authorized to hang gates at or near the top of the bank, across any road leading down the bank and terminating at such water-course, save in the limits of towns and cities.

RAILROAD, INTERURBAN, STREET-CAR, TELEGRAPH AND TELEPHONE LINES.

RAILROAD, ETC.—CROSSING STREAM OR HIGHWAY.

SEC. 35. Every steam or electric railroad company shall have the right to construct its railroad across any stream, water-course, road, highway, railroad or canal which the route of its road shall intersect, in such manner as not to interfere with the free use of the same and so as to afford security for life and property; but such railroad corporation shall restore and maintain the stream or water-course, road, highway or canal, thus intersected, to and in its former state, or in a sufficient manner not unnecessarily to impair its usefulness or injure its franchises. Whenever the track of such railroad shall cross a road or highway, such crossing may be at grade or such road or highway may be carried under or over the track, as may be most expedient; and, in cases where an embankment or cutting shall make a change in the line of such road or highway desirable, with a view to a more easy ascent or descent, the said railroad corporation may take such additional lands for the construction of such road or highway, or such new line as may be deemed requisite. Unless the lands so taken shall be purchased or voluntarily given for the purposes aforesaid, compensation therefor shall be ascertained in the manner provided by law, and duly made by such corporation to the owners and persons interested in such lands; and the same, when so taken and compensation made shall become part of such intersecting road or highway.

in such manner and on such terms as the adjacent parts of such highway may be held for highway purposes.

INTERURBAN—EXTENSION ON HIGHWAY.

SEC. 36. Any interurban or street railway company, organized under the laws of the State of Indiana and operating such railway within any of the towns or cities of the State, desiring to extend its road beyond such town or city limits on any public highway, or any other company organized under the laws of the State of Indiana for similar purposes, or any corporation desiring to build an interurban electric railway outside of any city or town on any public highway, may do so by procuring the consent of the board of commissioners of the county in which such highway is situated. If such highway is graveled or planked by a gravel or plank road company, such interurban or street railroad company shall also be required to procure the consent of such gravel or plank road company to run its road over such gravel or plank road. Such interurban or street railroad company shall, in all cases in which any road or highway shall be used by it for the purposes expressed in this section, locate its tracks on such part of such highway, keep its track and roadbed in such condition and perform such other reasonable terms and conditions as may be fixed in the order of the board of commissioners of the county made in granting such consent or at any time afterwards.

RAILROAD, ETC.—REAL ESTATE TAXATION.

SEC. 37. All officers engaged in the assessment of property for taxation are prohibited from assessing for taxation, against any adjacent property holder, the real estate occupied by any railroad, interurban or street railway, or by any public highway, and no part of the land so belonging to such property holder shall be assessed against him for taxation except the portion beyond the lines of the right of way of the railroad, interurban or street-car company or the right of way used and occupied as such public highway: Provided, That if the assessor and the land owner shall fail to agree on the amount of land contained in such railroad, interurban or street-car right of way, on such public highway, then such land owner, to receive the benefit of such exemption, shall determine the amount of land in dispute by actual survey and shall bear all expenses of the same.

POLES, WIRES, ETC.

SEC. 38. That corporations organized for the purpose of constructing, operating and maintaining telephone lines and telephone exchanges are authorized to set and maintain their poles, posts, piers, abutments, wires and other appliances or fixtures, upon, along, under and across any of the public roads, highways and waters of this State, outside of cities and incorporated towns; and individuals owning telephone lines are hereby given the same authority: Provided, That the same shall be erected and maintained in such manner as not to incommode the public in the use of such roads, highways and waters: Provided, also, That no pole or appli-

ance shall be so located as to interfere with the ingress or egress from any premises on said road, highway or waters: Provided, further, That nothing herein contained shall be construed as depriving the county commissioners of any county of the power to require the re-location of any such pole, poles or appliances which may affect the proper uses of such highway for public travel, for drainage, or for the concurrent use of other telephone lines; that the location and setting of said poles shall be under the supervision of the board of commissioners of the county.

BRIDGES.

BRIDGES—BUILDING OR REPAIRING.

SEC. 39. Whenever, in the opinion of the board of commissioners of any county, the public convenience shall require that a bridge upon any highway should be repaired or built, the board shall cause surveys and estimates therefor to be made and plans and specifications to be prepared and filed in the office of the county auditor, and shall direct such bridge to be erected or such repairs to be made. If, in the opinion of the board, the estimate therefor shall exceed the ability of the road district in which such bridge is to be built, or repairs to be made, by the application of its ordinary road work and tax, the commissioners may use any appropriation made from the county treasury to build or repair the same.

FUNDS.

SEC. 40. Such board of commissioners shall receive and appropriate all donations for the erection and repair of bridges, and shall make such regulations in reference to payments and kinds of bridges as to it shall seem proper.

SEALED PROPOSALS—CONTRACT—BOND.

SEC. 41. In case any board of commissioners determine that a bridge should be erected or repaired out of funds appropriated therefor from the county treasury, as provided in section thirty-nine of this act, such board shall direct the county auditor to advertise for sealed proposals to do the work according to the plans and specifications on file in his office. Such notice shall be given by publication for two weeks, once each week, in a newspaper of general circulation in the county, the last publication to be ten days before the day set for receiving bids. The commissioners may provide in such notice that each bidder, in guaranty of good faith and that he will enter into contract to do the work if his bid is accepted, shall deposit such money or give such bond as the board may deem proper, and may fix such other terms and conditions for the reception of bids as may be desirable. The board may let the contract to the lowest and best bidder, if his bid be reasonable, and may enter into written contract with him. But the board may reject all bids and re-advertise for other bids. Such contractor shall be required to give bond in an amount and with surety to be approved by the board, conditioned for the due performance of his contract.

PURCHASE OF BRIDGE—ABANDONED BRIDGE.

SEC. 42. The board of commissioners of any county may purchase any toll bridge, or buy any private interest therein, and order the same to be paid for out of any money appropriated therefor out of the county treasury; and whenever any bridge company has abandoned, or may abandon, any bridge, or when the right to take toll has expired, or may expire, it shall be lawful for the commissioners of the county in which such bridge may be situated to require the same, and the grades leading thereto, to be repaired; and for that purpose such board shall possess all the powers that are given by law to boards of commissioners for building and repairing bridges.

REPAIR OF BRIDGES.

SEC. 43. The board of commissioners of every county shall cause all bridges therein to be kept in repair, and shall cause the supervisor of the proper road district to keep in a conspicuous place at each end of any bridge in his district, whose chord is not less than twenty-five feet, the following notice in large letters: "One dollar fine for riding or driving on this bridge faster than a walk." And if any person shall ride or drive over any such bridge faster than a walk, or if he shall in any manner wilfully injure such bridge, he shall, for every such offense, forfeit and pay any such sum not less than one dollar nor more than treble the damages legally ascertained, to be recovered by the proper supervisor before any justice of the peace of the proper county, which sum so recovered shall be applied to the repairs of such bridges.

WITHIN CORPORATE LIMITS.

SEC. 44. The board of commissioners of any county may build or repair any bridge within the corporate limits of any city or town in such county; and any such bridge, if built or repaired by order of such board, shall be built or repaired in the same manner and paid for out of the same funds that other bridges without such corporate limits are by law built or repaired and paid for. Nothing in this section, however, shall be so construed as to take away from any such city or town the right to build or repair any bridge within its corporate limits, nor to take away the jurisdiction of such city or town over all bridges within such limits, whether built or repaired by such city or town or by the county board.

ACROSS BOUNDARY LINE—PROCEEDINGS, ETC.

SEC. 45. Whenever public convenience shall require the erection, repair or purchase of any bridge across a stream forming the boundary line between two or more counties in this State, the board of commissioners of such counties, upon application therefor, may, by order entered of record, declare its willingness to aid in the erection, repair or purchase of such bridge, and shall cause notice of such order to be given to the boards of commissioners of the other counties interested therein. And whenever it may be ascertained that each of such other boards has made

a like order, as shown by the certificates of the auditors of the respective counties, such boards shall, in case of the erection or repair of such bridge, by concurrent resolution, cause a survey and estimate to be made, submitting plans and specifications therewith, by some competent person, to be presented to such boards at a specified time and place when and where they shall meet in joint session at or near the site of such bridge, to estimate and determine the kind of bridge which shall be erected, or repairs made, and the manner and time of payments therefor; and they shall cause the plans and specifications that may be agreed upon at such meeting to be placed on file with the auditor of the county which first declared its willingness to aid in the erection or repair of such bridge, and a complete record shall be made by the auditor of such county of all the proceedings in relation to such bridge: Provided, That whenever a board of commissioners of any county shall have notified the board or boards of any other county or counties interested in the erection, repair or purchase of any bridge as specified in this section, and any such board of commissioners so notified shall fail or refuse for the period of thirty days to accept or act on the same by joining in the building, repair or purchase of such bridge, then the board or boards of commissioners passing such order, may, if in their opinion public convenience require it, build, repair or purchase such bridge under the same rules and regulations as are now or may hereafter be in force for the building, repair or purchase of bridges wholly within one county, after first having obtained, in case of the erection of a bridge, the written consent of the land owner in the adjoining county whose land will be occupied by such bridge. In case of the erection or repair of a bridge, it shall be the duty of such boards of county commissioners, while in joint session, to appoint one or more persons as superintendents, who shall have full control and supervision of the erection or repair of such bridge, subject, however, to such regulations as such boards of commissioners may determine upon; and such superintendent or superintendents shall each give bond in such sum as may be required by such boards of commissioners, and to be approved by them. It shall be the duty of such boards, in joint session, to fix the amount of the appropriation which should be made by their respective counties in payment of the cost of construction, repair or purchase of such bridge; which apportionment to each county of the whole cost of the construction, repair or purchase of such bridge shall be in proportion to the taxable property of such counties. In case of the refusal of any county, as aforesaid, to join in the construction, repair or purchase of such bridge, the county desiring such improvement may construct, repair or purchase such bridge, as hereinbefore provided, and when the cost of such bridge or repairs does not exceed five thousand dollars the county making such improvement shall be entitled to recover from each of such adjoining counties affected by such improvement the amount that such county should have paid had it joined in such improvement, such claim to be enforced as other claims are enforced against counties in this State; and when such claim is litigated the judgment shall include a reasonable attorney's fee for the plaintiff's attorney. All boards of commissioners, proceeding under this section to erect, repair or purchase joint bridges, in advertising for bids, letting contracts and requiring affidavits and bonds

for bidders and contractors, shall be governed by the laws now in force or hereafter enacted, providing for advertising for bids, letting of contracts and requiring affidavits and bonds of bidders and contractors for the erection of bridges wholly within and by one county. Each county shall be regarded as the owner of an interest in any bridge erected, repaired or purchased in pursuance of this section, and each shall have a voice in regulating the use thereof.

GRAVEL ROADS.

CONSTRUCTION BY ASSESSMENT—PROCEEDINGS.

SEC. 46. The board of commissioners of every county in this State shall have power, as hereinafter provided, to lay out, construct or improve, by straightening, grading, paving, draining, graveling or macadamizing any public highway, or any part thereof, within such county. Upon the presentation to any such board of a petition stating the kind of improvement prayed for, and the points between which the same is asked, signed by a majority of the adult resident landowners of the county whose lands will be benefited by the proposed improvement, such majority shall represent a majority of the acres owned by said residents, such board, if satisfied that due notice of such application has been given by publication, once each week for two weeks successively, in a newspaper published in the county, the last of which publications shall be at least ten days before the meeting of the board at which such petition is to be presented, or by posting up notices in three of the most public places in the neighborhood of such highway, at least ten days before such meeting of the board, shall appoint three disinterested freeholders of the county as viewers, and a competent surveyor or engineer to consider such proposed improvement and to proceed, upon a day to be named by the commissioners, or on any other day to which a majority may adjourn, prior to the next session of such board, to examine, lay out, straighten or otherwise improve such highway, as in their judgment public utility or convenience may require; and the auditor of the county shall notify such viewers and surveyor of the time and place of their meeting, and they shall meet accordingly, and after taking an oath or affirmation faithfully and impartially to discharge the duties of their appointment, respectively, shall determine what lands will be benefited or damaged by the proposed improvement, and shall take to their assistance two suitable persons as chain carriers, and one marker; and if the said viewers find [that] such improvement will be of public utility, and that the costs and expenses thereof and damages caused thereby will be less than the benefits to the lands within two miles of the improvement, excepting such lands and lots as lie within the limits of any incorporated town or city, they shall upon the actual view of all the lands within two miles of the improvement, excepting such lands and lots as lie within the limits of any incorporated town or city, apportion the estimated costs, expenses and damages upon all the said lands within such two miles that will be benefited, according to the benefits to be derived therefrom. They shall assess the damages, if any, to be sustained by any person or persons through whose lands such road is proposed to be laid out, straightened or improved.

VIEWERS AND SURVEYOR—REPORT—NOTICE.

SEC. 47. The viewers and surveyor, as soon as they have performed the duties prescribed by the preceding section, shall make a report to the board of commissioners, and file the same with the auditor of the county, which report shall show the public utility of the proposed improvement, an estimate of the costs and expenses thereof, including reasonable attorney's fees for the petitioners, the damages, if any, assessed to the several tracts of lands, the benefits to each forty-acre tract of land or less, where such exists, and give a description of the work proposed, the grade, drains, culverts, kind of improvement, the commencement, width and terminus of the road: Provided, That no lands shall be assessed for benefits that do not lie within two miles of the contemplated work or improvement, nor lands within incorporated towns or cities. As soon as such report is filed with the auditor, it shall be his duty to give notice of the filing thereof by publication for two successive weeks, once each week, in some newspaper published in the county where the improvement is to be made, and state therein the points between which such improvement is to be made, and the time set for the hearing of such report, the last of which publications shall be not less than ten days before the time set for such hearing.

HEARING OF REPORT—ORDER.

SEC. 48. At the time fixed for the hearing of the report, the board of commissioners shall proceed to hear the same, and if it is found that notice has been given, as required by the preceding section, that the proposed work is of public utility and that benefits assessed exceed the expenses and damages, such board shall enter upon its records an order that the improvement be made, which order shall state the kind of improvement and the width and extent of the same.

AMENDMENT TO PETITION.

SEC. 49. The board of commissioners shall have power to permit amendments to be made to the petition or report, and to extend the time to the viewers to make their report, and to continue the hearing from time to time, so as to subserve the ends of justice.

REMONSTRANCE—CAUSES.

SEC. 50. On or before the day fixed for the hearing of such report the owners of any lands affected by the work proposed may remonstrate against the report, which remonstrance shall be sworn to, and may be for any or all of the following causes:

First. That the report of the viewers is not according to law, stating specifically the illegality claimed;

Second. That the lands of the party filing the remonstrance are not benefited, or are assessed too much as compared with other lands assessed as benefited, specifying such lands;

Third. That the lands of the party filing the remonstrance are damaged, and that the damages assessed are inadequate;

Fourth. That it is not practicable to accomplish the proposed work without an expense exceeding the aggregate benefits;

Fifth. That the proposed work will not be of public utility.

If more than one party remonstrate, the remonstrancs shall be consolidated and tried together, and the report of the viewers shall be prima facie evidence of the facts therein stated. The board of commissioners shall try the issues thus formed, and if such board find for the remonstrants upon the fourth or fifth cause of remonstrance, the petition and report shall be dismissed at the cost of the petitioners: Provided, That if donations shall be made or secured to the satisfaction of the board, sufficient, with the assessments, to equal the expenses of the work and damages allowed, the petition and report shall not be dismissed for the fourth cause of remonstrance, and such donations are hereby authorized to be made. If the board find for the remonstrants upon the first cause of remonstrance, the report shall be referred back to the viewers for correction, or for a new report, to which new or amended report remonstrances may be filed as before; and if the report shall finally be made according to law the board shall find against the remonstrants for the first cause of remonstrance. If the board find for the remonstrants upon the second or third cause of remonstrance, such board shall modify the assessments and equalize the same and assess the damage as justice may require, and thus modified and equalized the assessments shall stand and be adjudged valid. The only questions that shall be raised shall be those raised by the remonstrance. If the assessment upon the lands of any remonstrant is not reduced twenty per cent. or the damages claimed by any remonstrant are not increased twenty per cent., such remonstrant shall pay all costs occasioned by such remonstrance; but if such assessment be reduced more than twenty per cent., or the damages be increased more than twenty per cent., then the remonstrant shall recover costs and the board shall apportion such costs pro rata upon the lands assessed for benefits. Such assessments when confirmed by the board of commissioners, or higher court on appeal, shall constitute first and paramount liens on the real estate respecively assessed, as taxes are liens, which liens shall relate back and bind the real estate so assessed from the time of the filing of the report. The auditor shall at once enter such assessments upon the tax duplicate, to be collected by the county treasurer as State and county taxes are collected, with interest at six per cent. per annum, [in] installments as hereinafter provided, and the moneys collected shall be used exclusively in payment of the bonds, costs and expenses of such work, as hereinafter provided.

SUPERINTENDENT OF CONSTRUCTION.

SEC. 51. After the improvement has been ordered and the assessments confirmed, as provided in the last section, the board of commissioners shall appoint a competent person to superintend the construction of the work, who, before entering upon the duties of such trust, shall take an oath or affirmation honestly, faithfully and impartially to discharge the duties of such trust, and shall execute a bond, payable to the State of Indiana, for the use of the parties interested therein, in double the amount of the assessments, with surety conditioned for the faithful performance

of the duties assigned him, which bond shall be approved by the board of commissioners. Suit may be brought on such bond by any person or corporation aggrieved, and any judgment rendered thereon in favor of any person or corporation shall be without relief from valuation or appraisement laws and with attorney's fees.

SUPERINTENDENT'S DUTIES.

SEC. 52. It shall be the duty of the superintendent charged with the execution of the work provided for in the preceding six sections to proceed to have the same constructed as ordered. He shall let the contract for such construction as a whole or in parcels, as he may deem best. He shall give notice of the time and place the contract or contracts will be let, by publication once each week for two successive weeks in one or more papers published in the county, which notice shall state the time within which the work is to be completed, and the parcel or parcels to be let. Sealed proposals shall be received, and the work let to the lowest responsible bidder or bidders. A bond with surety executed by the bidder to the State of Indiana, in the amount of the bid, shall accompany each bid. Such bond shall be executed by freehold sureties, at least one of whom shall be a resident of such county; or the bond may be secured by a surety company to the approval of the board. Suit may be brought on such bond on the relation of the superintendent or that of any person having an interest therein, for any and all breaches thereof, and any judgment rendered thereon shall be without relief from valuation or appraisement laws, and include reasonable attorney's fees. If any person or persons contracting to construct the work, or any part thereof, shall fail to perform the same according to the contract, the superintendent shall have the right to relet the same, on notice and after receiving bids as on the first letting, and deduct from the contract price of the original contract whatever sum the last contract is in excess of the original contract, and shall also deduct the expense of the reletting; and the superintendent shall have the right to continue the reletting as above until the work is fully completed.

ASSESSMENTS—PAYMENT—ISSUANCE OF BONDS.

SEC. 53. As soon as the contract or contracts are let for the construction of the work as provided in the preceding section, the superintendent shall assess upon all the lands benefited, ratably upon the amount of benefits as confirmed and adjudged by the board of commissioners, or court on appeal, such sum as may be necessary to pay for the work and all costs and expenses accrued or to accrue, not exceeding the whole benefits adjudged upon any one tract. He shall immediately thereafter make out a notice stating that the work has been established by the board of commissioners, setting out also the several assessments to the several tracts of land, as confirmed by the board, or court on appeal, and cause such notice to be recorded in the office of the recorder of the county. Whenever any assessment shall have been satisfied, it shall be the duty of the superintendent to enter satisfaction of the lien thereof in such record; and in case bonds are issued, as hereinafter provided, it shall be

his duty to enter on the margin of such record the words "bonds issued," which entry shall have the effect to transfer the record of the lien of any such assessment to the gravel road duplicate in office of the county treasurer. Should such superintendent fail to enter such satisfaction, the board, by order duly entered, shall direct the auditor to make such entry of satisfaction in the recorder's office. Such superintendent shall be liable on his bond to any person interested for such failure of duty. The superintendent of construction, out of the funds collected from the assessment so made and confirmed, shall pay all costs of the gravel road improvement not otherwise adjudged, and all expenses incident to the construction of the work, including the reasonable attorney's fees of the petitioner or petitioners in the preparation and presentation of the petition, the establishment of the work and other services rendered in such work, and also such other costs and expenses as the board shall allow; but no claim for costs or expenses, except payments on the contract for constructing the work, shall be paid until such claim is allowed by the board. All costs not taxable to the petitioner or petitioners, remonstrants or appellants, shall, in the first instance, be paid out of the county treasury, and shall be refunded to the county by the superintendent of construction out of the first moneys collected by him; next in order he shall pay all awards of damages; and thereafter he shall pay to the contractor such sums as shall from time to time become due under the terms of the contract, reserving, however, twenty per cent. thereof, which shall be due and payable only on completion and approval of the whole work. For the purpose of raising funds for making such payments, the superintendent shall collect of the assessments of benefits adjudged by the board, such sums as may be necessary therefor, not exceeding the whole amount of benefits assessed against any tract, and require the same to be paid to him in installments not exceeding ten per cent. per month, at such times and places as he shall fix, after thirty days' notice thereof given by one publication in a newspaper of general circulation published in the county. If any such assessment is not paid in the amount and at the time by him required, the superintendent shall make his certificate showing the amount of the assessment against any tract, and the default in its payment as required, and shall file the same with the auditor of the county; thereupon the auditor shall place such amount, together with ten per cent. penalty for the default, upon the tax duplicate, to be collected as state and county taxes are collected, at the next ensuing date for semi-annual payment of taxes. If such assessment and penalty are not then paid, an additional penalty of five per cent. shall be added, and the land shall be sold for such assessment and penalty with interest thereon at six per cent. from the date of last default to the date of sale, as lands are sold for the non-payment of delinquent taxes; and the redemption from such sale may be had in the same manner, during the same time and on the same terms as provided by law for the redemption of lands sold for delinquent taxes. Gravel road bonds may be issued to procure funds for the payment of the cost, damages and expenses of the construction of such work, and of the proceedings had therein, provided the owners of lands assessed for benefits shall, within thirty days from the establishment of the work and approval of the assessments of benefits and damages, file their written

requests therefor with the superintendent of construction. In such written request any such land owner shall agree that in consideration of the right to pay his assessment in ten yearly installments he will not make any objection to any illegality or irregularity, if any, in the proceedings up to and including the letting of the contract and the issuing of such bonds and that he will pay such assessments with interest as the same become due. The filing of such requests and the issue of bonds, if any there should be, shall in no manner affect the collection of assessments from land owners and others assessed for benefits who have not filed requests for the issue of bonds, and as to them the collection of the assessments as hereinbefore provided for shall be made as if no bonds were issued; and bonds shall be issued to cover only so much of the cost, damages and expenses of the work and of the proceedings had therein as is apportioned to the lands of those who have filed requests therefor, and shall be liens only on such lands and payable only out of the assessments made thereon. Such apportionment shall be made as follows: The superintendent of construction shall carefully ascertain the total original cost of the work, including all damages awarded to the owners of lands and all incidental expenses, and shall apportion such total cost, damages and expenses to the several tracts of land and parties assessed for benefits, in proportion to the assessments for benefits, not in any case exceeding such benefits. Thereupon the superintendent shall report all such facts to the board of commissioners, together with all such requests for bonds and waivers of irregularities by land owners, which report and waivers the board shall examine, and, if found correct, shall approve; whereupon such report and requests and waivers, with such approval, shall be entered in full in the order book of the board. The board of commissioners, after the entry of such order, shall direct the county auditor to prepare an assessment sheet, or gravel road duplicate, showing the total cost apportioned to all the parcels of land for which the owners of lands request the issue of bonds, with proper columns for the payment of installments and interest. And such auditor shall assess ratably from year to year upon such lands a sum sufficient to pay such bonds and interest as they severally mature. The first of such assessments shall be due and payable at the semi-annual payment of taxes next following the letting of the contract, and the remaining assessments on the same day each year thereafter for nine successive years, with interest at six per cent. per annum, payable semi-annually, on all unpaid assessments. Such assessments and interest shall be collected by the county treasurer as State and county taxes are collected, and shall be subject to the same penalties in case of non-payment when due; and all laws for the collection of delinquent taxes, and for the sale of lands for taxes and redemption from such sale, shall apply equally to the collection of such assessments. Any land owner desiring to relieve his land of the lien of such cost of gravel road improvement may, at any time, pay the whole amount of the unpaid installments, with all interest due thereon. The treasurer shall receipt for any payment on such installments, and mark such payment on the duplicate, as in the case of payment of taxes; and any such payment shall be a release of the lien of such cost, and of the assessment for such work, to the extent of such payment. As soon as such duplicate is so prepared, the

board of commissioners shall issue the bonds of the county to the amount of the cost so placed on the duplicate for collection. The bonds shall be numbered consecutively, and shall be in denominations of one hundred dollars or any multiple thereof, except that one bond may be for less than one hundred dollars. One-tenth of such bonds, as near as may be, shall fall due and be payable on the first day of June or December, as the case may be, following the next succeeding semi-annual payment of taxes; and one-tenth of such bonds, as near as may be, shall fall due and be payable on the same day every year thereafter, for nine successive years. All such bonds shall bear interest from the date of letting the contract for such work until the bonds are paid, respectively, at six per cent. per annum, payable semi-annually, on the first day of June and first day of December, each year. They shall show on their face for what purpose issued; and shall be payable out of collections made on such assessments, and not otherwise. Upon the signing of such bonds by the board of commissioners and the attestation thereof by the county auditor, they shall be turned over to the county treasurer, who shall receipt to the auditor therefor. Thereupon the treasurer shall give notice, by publication once in a newspaper of general circulation published in the county, and by posting a copy of such [notice] at the door of the court house, that, at the office of such treasurer, on and after the hour of ten o'clock a. m., on a day to be named, not less than twenty days thereafter, the treasurer will proceed to sell such bonds, at not less than the principal sum named in such bonds, to the highest and best bidder for cash: Provided, however, That in lieu of selling such bonds, as herein provided, the board of commissioners, by order of record to that effect, may direct that the bonds shall be exchanged at par and held by the county treasurer for any unloaned school funds or other unused funds held in the county treasury; in which case the assessments and interest collected for the payment of such bonds shall be paid into and credited to the fund so used in their purchase. The proceeds of such bonds shall be drawn out of the county treasury only on the warrant of the auditor, upon the certificate of the superintendent, in payment of the cost of construction of such work and the expenses incident thereto. In case the bonds sell at a premium, the aggregate amount of such premium shall be apportioned pro rata to the several assessments of cost against the respective parcels of land; and the amount thus apportioned to each parcel shall operate as a payment, to that extent, of the first maturing installment.

ACCEPTANCE—FINAL REPORTS—SURPLUS FUNDS.

SEC. 54. When the work of graveling, macadamizing or otherwise improving such highway, as hereinbefore provided, is completed, and the superintendent shall certify the same to the auditor of the county, the board of commissioners shall receive the improvement and provide for the keeping of such road in repair, as hereinafter required. It shall be the duty of the said superintendent, within sixty days after certifying the completion of the improvement, to file his report with the auditor, showing the receipts and disbursements, accompanied with vouchers for all disbursements, which report shall be submitted by the auditor to the

board of commissioners at their next ensuing term, for approval or rejection. As soon as such report shall have been approved by the board of commissioners, the superintendent shall, within ninety days thereafter, distribute the surplus funds, if any, remaining in his hands to the persons from whom the same were collected, according to the several assessments, and take vouchers therefor; and as soon as he has completed such distribution he shall file his report thereof, accompanied by such vouchers, with the board of commissioners, for approval or rejection, and when the same has been approved, he shall be discharged by order of the board. If for any reason any surplus funds remain in the hands of the said superintendent after having made distribution the same shall be ordered paid into the gravel road repair fund, to be used only in the repair of the road for the construction of which the funds were collected. Whenever the owner of any tract of land assessed for the construction of any such road shall have paid off such assessments, it shall be the duty of the auditor to release and satisfy such assessment lien by writing the appropriate words of such payment and satisfaction upon the record where such assessment appears, and sign his official signature to such release, with the date thereof.

CONTRACTOR—PURCHASE OF MATERIALS.

SEC. 55. Any contractor for the construction of such work, or any part thereof, as provided for in the preceding nine sections of this act, shall have the power to contract for and purchase any materials that may be necessary for the construction of such road; and if such contractor can not agree with the owner of such materials, as to the price thereof, he may apply to the circuit court of the county, or the judge thereof in vacation, to appoint appraisers to condemn and assess the value of such materials as provided by law for the condemnation of real estate under the power of eminent domain. The appraisers shall also assess the damages that may accrue to the owner of such materials by the removing of the same through his premises, and shall immediately return their award to such circuit court, or to the judge thereof in vacation; and such court or judge shall, upon the return of such award, on application of such contractor, furnish him with a copy of such award. Thereupon such contractor shall enter upon the lands, either enclosed or unenclosed, and remove such materials as may be required to make a good road. An appeal from such award by the owner shall not prevent the immediate entry upon the premises by the contractor for the purpose of taking such materials. If the contractor appeal and the award be not reduced ten per cent. thereof, he shall pay all costs occasioned by the appeal; and if the owner of the materials appeal and do not receive ten per cent. more than the award, such owner shall pay all the costs occasioned by the appeal.

REMONSTRANCE APPEAL—QUESTION FOR TRIAL—COSTS, ETC.

SEC. 56. Any person who appeared and filed a remonstrance before the board of commissioners as provided for in section fifty of this act, shall be allowed an appeal to the circuit court, in like manner as other

appeals are now allowed; and on such appeal the only question that shall be tried in the circuit court shall be the question raised before the board of commissioners by the first, second or third causes of remonstrance, which questions shall be tried by the court without a jury. On such trial the report of the viewers shall be prima facie evidence of the facts therein contained. If more than one party appeal all such appeals shall be consolidated and tried together, and the rights of each appellant separately determined. If the court find for any appellant upon the first cause of remonstrance the report shall be referred back to the viewers for correction, or for a new report; and if the report as so amended is found to be correct it shall be approved by the court. If the court find for any appellant upon the second or third cause for remonstrance, it may modify and equalize the assessments as justice may require, by diminishing or increasing any assessments or benefits, or by giving or withholding, increasing or diminishing, damages. For the purpose of so ruling upon such causes of remonstrance, and so modifying the assessments, all persons or corporations who are reported as affected, or whose lands are reported as affected, or who are named in the petition as affected, or who have appeared to the petition, shall be deemed to be in court for all purposes, by reason of such appearance or by virtue of the notices theretofore given them; and as thus modified and equalized the assessments shall stand and be adjudged valid. Such judgment of the court shall be final, and no appeal be allowed therefrom. If the assessment upon the lands of any appellant is not reduced twenty per cent. or the damages awarded by the board of commissioners are not increased twenty per cent., such appellant shall pay all the costs occasioned by such appeal, but if such assessment be reduced more than twenty per cent., or if the damages be increased more than twenty per cent., then the appellant shall recover costs, and the court shall apportion such costs pro rata upon the lands assessed for benefits: Provided, That the decision of the board of commissioners as to the fourth and fifth causes for remonstrance shall be final and no appeal shall be allowed therefrom: And provided, further, That if any appeal is taken from the board of commissioners to the circuit court, the bonds hereinbefore provided for shall not issue until after the final judgment of the circuit court on such appeal.

ERROR IN PROCEEDINGS.

SEC. 57. No person shall be permitted to take advantage of any error committed in any proceedings to lay out, construct or improve any highway under and by virtue of this act, nor of any error committed by the board of commissioners, or by the county auditor, or by the engineer, surveyor, superintendent or other person or persons in the proceedings to lay out, construct or improve any such road, nor for any informality, error, or defect apparent in the record of such proceedings, unless the party complaining is affected thereby.

TAXATION IN CITIES OR TOWNS.

SEC. 58. When any highway to be improved under and by virtue of sections forty-six to fifty-seven, inclusive, of this act, begins or terminates in any city or town, the corporate authorities of such city or town

may, on agreement with the board of commissioners, levy a tax for the payment of an amount not exceeding one-fifth of the entire cost of such improvement, in addition to any amount that may be assessed upon the real estate in such city or town by virtue of the provisions of said sections: Provided, That the entire tax to be imposed for road purposes by virtue of this section shall not in any one year exceed fifty cents on the one hundred dollars of taxable values of such city or town.

INTO ADJOINING COUNTY.

SEC. 59. When it may be desirable to continue any highway improvement contemplated under the provisions of the preceding sections from forty-six to fifty-eight, inclusive, into or through an adjoining county, the same proceedings shall be had in such county as to petitions, bonds, viewers, appraisements and all other formalities as are prescribed in said sections for the commencement of such improvement in the first county, and all such proceedings shall be had before the board of commissioners of the county in which such proposed extension is located.

ONE MILE OR LESS.

SEC. 59½. Whenever there shall be constructed in any county of this State any public gravel road or turnpike not less than one (1) mile in length, except where the entire length of the road is less than one (1) mile, and connecting with any free gravel road or terminating at any town or city, the same having a substantially graded roadbed not less than twenty (20) feet wide, with suitable side drains, culverts and bridges, and with grades not exceeding the maximum of free gravel or turnpike roads of such county, and having placed thereon not less than one (1) yard of suitable gravel or broken stone for every three (3) feet in length in such manner as to make a suitable road for public travel; that on the written request to the board of commissioners for such county, of not less than three (3) freeholders residing in the road district wherein such road is situated, said board of commissioners shall make inspection thereof, and for such purpose may employ a competent engineer to assist them. If upon such examination such road in their opinion is of public utility, and shall conform to the requirements herein, they shall cause an entry to be made on their records of such facts, and also enter thereon a description of the commencement and terminus thereof, and general description of the route of the same, and thereafter such road shall be deemed a part of the free gravel or turnpike roads of such county, and maintained as by law provided.

ON COUNTY LINE—PROCEEDINGS.

SEC. 60. When it is desirable to make any gravel or other highway improvement upon the boundary line between two counties, such as the improvements contemplated in the preceding fourteen sections, the petition therefor may be filed before the board of commissioners of either county, and such board shall direct the county auditor to transmit to the board of commissioners of the other interested county a copy of such petition and

a notice of the time and place when and where both boards shall meet to act upon the petition. Such meeting shall be held not less than twenty days nor more than thirty days from the date of the giving of such notice and transmitting of such copy of such petition. The two boards shall act together in all matters relating to such improvement. The same proceedings shall be had as near as may be, as to the petition, viewers, assessments, superintendent, bonds and all other matters as are prescribed in said foregoing sections of this act in relation to gravel road and other like improvements aforesaid when made in one county. Should the board of commissioners of such second county refuse or neglect to meet and act with the board of the first county, then said first board, before which the petition was filed, may proceed to make the improvement on such boundary line, as if the highway were wholly in the first county, and shall have power to make all assessments on lands within two miles on each side of such line; and such first county shall have a claim upon such second county for one-half of all necessary expenses paid out of the treasury of the first county in relation to such work, which claim may be collected from the second county as any other claim due from one county to another. Whenever a petition for any such improvement of a highway on the boundary between this State and any other State is filed before the board of commissioners of any county adjoining such other State, such board of commissioners and the other proper officers of such county shall have authority to unite with the proper officers of any adjoining county in such other State in the doing of such work, in accordance, so far as may be, with the proceedings herein authorized when the highway is on the boundary line between two counties: Provided, That the adjoining county or counties in such other State shall pay one-half of all expenses and assessments for the construction of such improvement and shall thereafter keep one-half of such highway in repair. The commissioners and other proper officers in such adjoining county in this State are given full power to enter into any equitable contract with the proper authorities in such adjoining county or counties in such other State to do such work and keep up such repairs in accordance with the laws of this State for making and keeping up such improvements in any county of this State, so far as the same can be made applicable.

FREE OF TOLL—TOWNSHIP ROAD FUNDS.

SEC. 61. All highways improved under the provisions of sections forty-six to sixty, inclusive, of this act shall be free of toll. Nothing in said sections shall be so understood as to prevent township trustees from grading, graveling, macadamizing or otherwise improving the highways in their several townships and paying for the same out of the road funds of such townships.

GRAVEL ROADS BY TAXATION.

TOWNSHIP CONSTRUCTION, ETC., BY TAXATION.

SEC. 62. The boards of commissioners of the several counties of the State of Indiana are hereby authorized and empowered to lay out, establish and cause to be graded, drained and paved with stone, gravel or other

road-paving material any new highway or part of a highway in any township in said State, or on the line dividing any two or more townships in any county in this State, or to cause to be graded, drained and improved in like manner any public highway already established in any such township or on the line dividing any two or more of such townships, in the manner and upon the conditions hereinafter prescribed.

PETITION—NOTICE.

SEC. 63. Whenever a petition signed by fifty or more freeholders and voters of any township in any county in this State, includes any incorporated town or city in such township having a population of less than thirty thousand inhabitants, praying that any public highway or highways within such township shall be laid out, established and improved by grading, draining and paving with stone, gravel or other road paving material, or that any public highway, or highways, or any part of any public highway, or highways, already established, shall be graded, drained and paved with stone, gravel or other road-paving material, or by fifty or more freeholders and voters of two or more townships in such county praying that a public highway shall be laid out, graded, drained and paved on a line dividing such townships, or that a highway on such line shall be graded, drained and paved, shall be addressed to the board of commissioners of the county in which such township or townships are located, and filed in the office of the auditor of such county, it shall be the duty of such auditor to cause to be published in a weekly newspaper of general circulation, printed and published in said county, and to be posted in not less than three public places within each of the townships named in such petition, and at the door of the court house of such county, a notice setting forth a copy of such petition, and the day upon which the same will be presented to such board of commissioners.

CONTENTS OF PETITION.

SEC. 64. The petition herein contemplated shall set forth the beginning, course and termination of each new highway or part of highway sought to be laid out, established, graded, drained and paved, and the beginning and termination and a general description of each public highway sought to be graded, drained and paved, together with a recommendation of the width of each such highway and of the character of the improvement to be made, and such petition may include one or more of such highways at the option of the petitioners.

PRESENTATION TO COMMISSIONERS.

SEC. 65. Upon the filing of such petition the auditor shall designate by endorsement thereon the day in a regular session of such board of commissioners, not more than thirty days thereafter upon which the same shall be presented to such board and the notice herein prescribed shall be signed by such auditor and published for two consecutive weeks in such newspaper, and posted not less than fifteen days, before the day so designated by the auditor.

HEARING ON PETITION—PROOF—ENGINEER—VIEWERS.

SEC. 66. On the day so designated, by such auditor, the petitioners may make proof of the publication and posting of such notices and present such petition to such board of commissioners, and any taxpayer of any township named in such petition, or any person or corporation whose lands or property will be affected by the work therein prayed for, may file in writing his objections to the form or sufficiency of such petition, and in the event that such board shall deem such petition to be deficient in form, or insufficient in substance, the petitioners shall be permitted to amend the same, but if such petition be not amended in such manner as to be in due form and sufficient, it shall be dismissed at the cost of the petitioners. If on the other hand such petition shall be adjudged by the board to be in due form and sufficient, either in the first instance or after the same has been amended, such board of commissioners shall make an order causing such petition to be spread of record and referring the matter therein prayed for to a competent civil engineer to be appointed by such board and two viewers, each of whom shall be a responsible freeholder and voter of such county, and not a resident of, nor the owner of taxable property in any township named in such petition.

ENGINEER AND VIEWERS—OATH—BOND.

SEC. 67. Such engineer and viewers shall meet at a time and place to be designated by such board of commissioners, within ten days after their appointment, and shall each take and subscribe an oath faithfully and impartially to discharge his duties, and such engineer shall execute, and file with such auditor, his bond, with good and sufficient sureties to the approval of such auditor, payable to the State of Indiana, in a penal sum of five thousand dollars, conditioned for the faithful discharge of his duties as such engineer, which bond may be put in suit by any person or corporation whose property shall be injured or damaged by any wrongful act or negligence of such engineer.

DUTIES OF ENGINEER AND VIEWERS—REPORT—PROFILE.

SEC. 68. When such engineer and viewers shall have taken the oath, and such surveyor has executed the bond, herein prescribed, they shall proceed, without delay, to view and make all needful surveys of the road or roads mentioned in the petition, and shall determine

(a) Whether any proposed new highway or part of highway described in the petition will be of public utility;

(b) In respect to each separate highway or part of highway named in the petition, whether it will be of public utility to grade, drain and pave the same as therein prayed;

(c) The width of each highway or part of highway to be established or improved;

(d) The character of the improvement, including the grading, draining and paving, to be made of each highway mentioned in the petition, which they shall find to be of public utility, together with complete plans and specifications of each such improvement and of all bridges, culverts and waterways required therein;

(e) The estimated cost of each improvement to be made.
And on a day to be designated by such board of commissioners, in the order appointing them, said engineer and viewers, unless the time therefor shall have been extended by an order of said board, shall file in the office of said auditor their report in writing, signed by each of them, setting forth their determination in said matter in respect to each highway or proposed highway mentioned in the petition, including an accurate description of each new highway to be laid out, established, graded, drained and paved, and of each public highway to be graded, drained and paved, together with their recommendations in respect to the paving materials to be used in each instance and complete plans and specifications for each improvement to be made, and the estimated cost of each such improvement, and such report shall be accompanied by an accurate profile of each highway or part of highway to be improved, showing by proper lines and figures the elevation thereof at each one hundred feet of its length and the changes to be made therein by excavation or filling, which profile shall be made by the engineer.

ASSESSMENT OF DAMAGES—CLAIMS.

SEC. 69. The report and profile of the engineer and viewers shall remain in the office of such auditor, open to the inspection of every person interested therein and of his agents and attorneys for at least ten days, and during such time said viewers shall assess such damages as shall be justly due to any infant, idiot or person of unsound mind, and to any other person or corporation making written claim therefor, on account of the appropriation of or injury to his property by the laying out and establishment of any such new highway or any improvement of any highway prescribed in such report. At the next regular session of such board of commissioners, after the expiration of said ten days, said viewers shall make to said board their supplemental report in writing setting forth the sums allowed as damages to each infant, idiot or person of unsound mind, and the sum allowed as damages to each other person or corporation making written claim therefor as herein prescribed, together with a description of the property in each case on account of which such damages have been allowed. No damages shall be allowed to or recovered by any person other than an infant, idiot or persons of unsound mind, unless claim therefor shall have been made by him to such viewers before the filing of such supplemental report. Every person or corporation who has made such written claim for damages, and every infant, idiot or person of unsound mind or his guardian, who shall be dissatisfied in respect to the action of such viewers in respect to his claim or in respect to the damages allowed to him, may except to such supplemental report in writing on that account at the session at which the same is filed, whereupon such board of commissioners shall appoint three other viewers to reconsider the same, which viewers shall take and subscribe an oath faithfully to discharge their duties, and shall examine the lands or property claimed to be affected and assess such damages in each case as they deem to be just and reasonable, and make report of their doings in writing to said board. The board shall cause said supplemental report and the

report of such additional viewers to be spread of record, and in event that the road or improvement on account of which such damages are allowed shall be finally established and ordered to be constructed, such damages shall be paid out of the proceeds of the sale of the bonds hereinafter authorized: Provided, That if the amount of damages awarded by the reviewers is not 10 per cent. greater than the amount assessed by the reviewers, the claimant shall pay all costs made by said reviewers.

ORDER FOR ELECTION—WHEN MADE—NOTICE.

SEC. 70. When all matters in respect to damages have been determined finally as hereinabove provided, such board of commissioners shall examine the reports and profile made by engineer and viewers and if they find and adjudge the same to be in due form and sufficient, they shall make an order requiring the auditor to give notice by publication for three consecutive weeks in a weekly newspaper of general circulation, printed and published in said county, that on a day to be named by the board the polls will be opened at the several voting places in each township named in the petition and report for the purpose of taking the votes of the legal voters thereof upon whether the proposed new highway or highways named in the petition and report shall be laid out, established, graded, drained and paved, or the public highway or highways named therein shall be graded, drained and paved, and that said petition and report and all records and matters pertaining to said matters may be found at the office of said auditor, and the auditor shall publish such notice as required by the order: Provided, That said publication shall contain the report of the viewers and engineer, excepting the plats and profiles: And provided further, That if any petition filed as provided in section 62 of this act calls for the building or improvement of a road less than three miles in length connecting at each end with an improved free gravel or macadamized road either within said township or townships or at the boundaries thereof, the board of county commissioners may in their discretion, if they find said petition otherwise complies with this act, establish and order the construction of said road without submitting the question of building the same to an election of the voters of the township or townships concerned, and when said board shall so decide they shall proceed to have said road constructed in all other respects as if submitted to an election and voted as hereinafter provided.

OPENING OF POLLS—RULES—BALLOT—CANVASS OF VOTE.

SEC. 71. On the day named in said notice such polls shall be opened and the votes of the legal voters shall be taken upon the matters named therein, and such election shall be governed in all respects by the general laws of this State concerning elections in so far as the same are applicable. The board of election commissioners for such election shall consist of the auditor and two commissioners to be appointed by the board of commissioners, and they shall prepare and cause to be printed the ballots therefor and distribute the same in the manner required by law. The ballots shall set forth a description of each highway and proposed high-

way in question, and following the description in each instance there shall be printed two squares and words as follows:

| YES | For the road.

| NO | Against the road.

Each voter desiring to vote for the establishment or improvement of any such road shall mark a cross with a blue pencil in the square containing the word "Yes," and each voter desiring to vote against such establishment or improvement shall mark such cross in the square containing the word "No." The votes cast at such election shall be canvassed at the office of such auditor on the Thursday next following the election, and a certificate of the votes cast for and against each road or improvement, signed by the inspectors, shall be filed with said auditor and by him shall be submitted to the board of commissioners at their next session. If a majority of the votes cast at any such election be found to be in favor of the establishment and improvement, or improvement of any such road or proposed road, the board of commissioners shall make an order establishing such road or work and requiring the same to be laid out, established, graded, drained and paved, or graded, drained and paved, as the case may be, in accordance with the terms of the report and the plans and specifications and profile therefor.

SEPARATE ROADS—PETITION—VOTING ON WHOLE—TOWN OR CITY.

SEC. 72. If all of the roads described in the report of the engineer and viewers are connected with each other so as to form one system, the whole may be voted upon as one road, if the petitioners so pray in their petition. If two or more petitions respecting roads in the same township shall be pending at the same time, they shall be voted upon at the same election. No street in any incorporated town or city shall be improved under the provisions of this act without the consent of the trustees of said town or the common council of such city, by resolution duly adopted, a certified copy of which resolution shall be filed in the office of such auditor and entered upon the records of such board before such improvements shall be ordered. After any street shall have been improved hereunder, the trustees of such town or the common council of such city shall have control of the same and shall maintain the same in repair.

NOTICE TO BIDDERS.

SEC. 73. When any such highway or part of highway shall have been ordered to be laid out, established, graded, drained and paved, as herein provided, or any public highway or part thereof, shall have been ordered to be graded, drained and paved, as herein provided, it shall be the duty of the board of commissioners to make an order requiring the auditor to give notice by publication one time in a daily newspaper of general circulation throughout this State, published at Indianapolis, and by publication for three consecutive weeks in a weekly newspaper of general circulation printed and published in the county, that on a day to be named by such

board in such order, sealed proposals will be received by said board for the making of said improvements in accordance with said profile and report and the plans and specifications therein set forth. If there be more roads than one the notice shall relate to all. The auditor shall give the notices as ordered, and the notice to be published at Indianapolis shall be published at least two weeks before the day named therein. If the board deems it advisable, it may require similar notices to be posted at public places in the township in which the road or roads are located.

CONTRACT—BOND BY BIDDER.

SEC. 74. On the day and at the time and place named in the notices the board shall convene in session and shall receive all sealed proposals tendered and shall open the same in the presence of the bidders and shall let the contract for the construction of such road or improvement to the lowest responsible bidder therefor, but no contract shall be let for a bid higher than the estimates made by the viewers: Provided, That with his proposal such bidder shall submit his bond, payable to the State of Indiana, in a penal sum equal to double the sum of his proposal, with good and sufficient sureties to the approval of the board, conditioned for the faithful performance of the work in accordance with the profile and report and the plans and specifications therein set forth, which bond shall be for the benefit of any person or corporation who shall suffer loss or damage by reason of any failure or neglect of such bidder to enter into a proper contract to perform such work or to carry out the same in any particular, or to pay for any labor or material therefor that shall have been furnished either to him or to any sub-contractor, agent or superintendent under him. If the proposal includes more than one highway or improvement one bond covering all shall be sufficient.

BONDS—INTEREST.

SEC. 75. For the purpose of raising money to pay for construction the board of commissioners shall issue the bonds of the county not to exceed in amount the contract price and all expenses incurred and damages allowed prior to the letting of the contract and a sum sufficient to pay the per diem of the engineer and superintendent hereinafter provided for during the construction of the work in denominations not less than fifty dollars ($50.00) each in forty (40) equal series, the first series payable in six (6) months, the second series in one year, the third series in one year and six months, the fourth series in two years, the fifth series in two years and six months, the sixth series in three years, the seventh series in three years and six months, the eighth series in four years, the ninth series in four years and six months, the tenth series in five years, the eleventh series in five years and six months, the twelfth series in six years, the thirteenth series in six years and six months, the fourteenth series in seven years, the fifteenth series in seven years and six months, the sixteenth series in eight years, the seventeenth series in eight years and six months, the eighteenth series in nine years, the nineteenth series in nine years and six months, the twentieth series in ten years, the twenty-first

series in ten years and six months, the twenty-second series in eleven years, the twenty-third series in eleven years and six months, the twenty-fourth series in twelve years, the twenty-fifth series in twelve years and six months, the twenty-sixth series in thirteen years, the twenty-seventh series in thirteen years and six months, the twenty-eighth series in fourteen years, the twenty-ninth series in fourteen years and six months, the thirtieth series in fifteen years, the thirty-first series in fifteen years and six months, the thirty-second series in sixteen years, the thirty-third series in sixteen years and six months, the thirty-fourth series in seventeen years, the thirty-fifth series in seventeen years and six months, the thirty-sixth series in eighteen years, the thirty-seventh series in eighteen years and six months, the thirty-eighth series in nineteen years, the thirty-ninth series in nineteen years and six months, the fortieth series in twenty years from the 15th day of November or the 15th day of May, as the case may be, after the date of their issue, said bonds bearing interest not higher than four and one-half per cent. per annum, and the principal and interest thereon both to be paid semi-annually on the 15th day of November and the 15th day of May: Provided, That the petitioners for the improvement of any road or roads, as in this act provided, may, in their petition, ask that the issue of bonds to be issued and sold to raise moneys to pay for such improvement be issued in series, payable in not less than ten years and not to exceed twenty years in the denominations named in this act, as the petitioners may designate in their petition, and the board of county commissioners shall issue the bonds for such improvement in compliance with the request of such petitioners: Provided, further, If the petitioners in any such petition fail to ask for any certain term of years in which such bonds shall be payable, then in case of such failure the board of county commissioners shall designate and determine the term of years for which such bonds shall issue and be payable. Such term to be not less than ten, nor more than twenty years. The county treasurer shall sell bonds at not less than their face value, and the proceeds shall be kept as a separate and specific fund to pay for the construction of the particular road or roads for which they were issued, and shall be paid by him to the contractor upon warrant of the auditor, as directed by the board of commissioners. The commissioners shall order the same to be paid in such amount and at such times as they may agree, but no payment shall be made by the commissioners for more than eighty (80) per cent. of the engineer's estimate of work done by the contractor, nor shall the whole amount of the contract be paid until the road shall have been received as completed by the board of county commissioners.

TAX TO PAY BONDS.

SEC. 76. For the purpose of raising money to meet said bonds and interest thereon, the board of commissioners shall annually thereafter, at the time the general tax levy is made, levy a special tax upon the property of the township or townships, including the towns and cities, if such there be, of less than thirty thousand (30,000) inhabitants, in such manner as to meet the principal and interest of said bonds as they become due, and such tax shall be collected as other taxes, and shall be applied to the pay-

ment of such bonds and interest. If the road or section thereof so constructed runs into or through two or more townships, the amount paid thereof [thereon] shall be divided and charged upon the property of each township, in the same ratio that the assessed valuation of all the property in each township bears to the assessed valuation of all of the property in all of the townships through which the said road or roads runs, and said special tax be levied accordingly. That when any contract shall have been awarded to any contractor for the construction of said road or roads under this act he shall give preference in employing labor for the construction of said road or roads to the citizens of the township or townships, towns or cities in which said road or roads are to be constructed: Provided, however, That said preferred labor shall be as good and effective as that which could be procured elsewhere, and at no higher cost: And provided further, That any taxpayer of the township or townships where said roads are, who may render any service or labor, or may furnish any material for the construction of said roads, may, if he shall so elect, demand of the contractor a certificate stating the value of the amount of service or material furnished, and if any such certificate shall be issued the county treasurer shall receive the same and it shall act as a quietus against a similar amount of taxes against the property of said taxpayer, and all such certificates shall be deducted from the contract price of the said road or roads by said contractor.

FREE OF TOLL—REPAIR.

SEC. 77. All roads built under this act shall be free of toll, and shall be kept in repair the same as other free gravel roads constructed under the other laws of the State are repaired.

SURPLUS TAX.

SEC. 78. After the payment of the costs of construction of said road or roads, should there be any surplus collected or due on delinquent taxes for that purpose, it shall be transferred to the gravel road repair fund.

AMENDMENTS—SUPERINTENDENT—BOND.

SEC. 79. The board of county commissioners shall have power to permit amendments to be made to the petition of said freeholders, or report of viewers and to extend the time to the viewers to make their report and to continue the hearing from time to time, so as to subserve the ends of justice. It shall be the duty of the board of county commissioners to appoint a competent superintendent to supervise the construction of such road or roads according to the plans, profiles and specifications filed by the engineer and viewers, on which the contract to construct such road or roads was let. He shall be a resident of one of the townships in which the road or roads are located, and his compensation shall not exceed two dollars ($2.00) per day for the time actually employed, to be paid out of the construction fund of said road or roads, and he shall render an account of his time to the commissioners monthly at the regular

term of their court, subscribed by oath. He shall give bond in the penal sum of five thousand dollars for the faithful discharge of his duties. The engineer of such road or roads shall also give bond in the penal sum of six thousand dollars for the faithful discharge of his duties, and said superintendent or engineer or both if in default, shall be liable to the township or townships constructing such road or roads on such bond or bonds at the suit of any taxpayer interested in such road or roads for failure to cause said road or roads to be built and constructed according to the plans, profile and specifications under which the contract to construct the same was let.

RECORD—COUNTY AUDITOR.

SEC. 80. The county auditor shall make a complete record of all proceedings in making such improvements.

LIMIT AS TO BONDS.

SEC. 81. It shall be unlawful for any board of county commissioners to issue bonds, or any other evidence of indebtedness payable by taxation, for the construction of free gravel or macadamized roads, when the total issue for that purpose, including bonds already issued and to be issued, is in excess of four (4) per centum of the total assessed taxable valuation of the property of the township or townships wherein such roads are located or to be located, and all bonds or obligations issued in violation of this act shall be void.

COMPLETION—REPORT—FINDING—APPEAL.

SEC. 82. Whenever any superintendent and the engineer of any road or roads constructed under the provisions of this act, believes that the road or any part thereof, less than the whole of such improvement is completed, as required and according to the plans, plats, profiles and contract, under which the improvement was let, then such superintendent and engineer shall each file their sworn statements with the auditor of the county, which sworn statements shall state that such road or roads, or part thereof, has been completed according to the plans, plats, profiles and contract, under which said improvement was let, and that the quantity and quality of material used in making said improvement was the kind of material, and that the quantity was used as required in the contract, the board of county commissioners shall not act on such proof of the completion of such road or roads or part thereof, until the said sworn statements have been filed with the auditor at least ten days before the first day of any regular term of said board, and if, within said ten days, any taxpayer interested in such improvement shall file his sworn statement with the auditor that such road or roads or part thereof has not been completed according to the plans, plats, profiles, and contract under which such improvement was let, and states specifically in what particular the same has not been completed, then, in such case, the board of county commissioners shall set a day for hearing such issue and hear other proof on such matter, and may cause witnesses to be subpoenaed, and hear sworn evidence in

the same manner as other issues are heard before the board of commissioners. And if the board of county commissioners find that such road or roads or part thereof, has been completed according to the plans, plats, profile, and contract under which such improvement was let, then such board of commissioners shall accept and receive such road or roads or part thereof, but if the board of county commissioners find that such road or roads or part thereof has not been so completed, then such board shall refuse to accept the same and require the contractor to complete the same according to the plans, plat, profiles and contract: Be it further provided, That if the board of commissioners find that such road or roads or part thereof has been completed according to contract, then in such case the taxpayer who filed his affidavit and formed said issue shall pay all costs, made in any such hearing, and a judgment shall be rendered against him for the same; but if they find that the road or roads or part thereof has not been completed according to contract, then the costs made in such hearing shall be paid by and judgment rendered against the contractor for the same: Provided further, That such taxpayer or contractor may appeal from such decision and finding of the board of commissioners to the circuit court of the county at any time within thirty days from such decision, upon filing a bond to the approval of the auditor of the county, conditioned for the payment of all costs in the cause that may be adjudged in the circuit court against the person taking such appeal, such proceedings to be tried de novo in the circuit court.

ADDITIONAL BONDS.

SEC. 83. Whenever in any proceedings heretofore had under the provisions of an act of the general assembly of the State of Indiana entitled "An act concerning the location and construction of free gravel, stone or macadamized roads, providing for raising funds to pay for the same and for their maintenance, and providing for the repeal of other acts touching the same subject-matter, and declaring an emergency," approved March 11, 1901, or under said act and acts amendatory thereof or supplemental thereto, the board of commissioners of any county shall have erroneously let a contract for the construction or improvement of any free gravel, stone or macadamized road or roads, in any township, at a contract price, within the estimates made by the viewers, but in a sum so large as not to leave sufficient of the funds realized from the sale of bonds in the same proceedings to pay the sum named in said contract and also the other expenses incurred in such proceedings, such board of commissioners, for the purpose of raising money to meet such deficiency, shall issue and sell additional bonds of the county in an aggregate sum equal to such deficiency, but in no event in excess of five per centum of the original estimates in said proceedings, payable within five years, in the same manner, with interest at the same rate and out of funds raised by the same process, as in the case of other bonds issued in the same proceedings.

PURCHASE OF TOLL ROADS—PETITION—APPRAISEMENT—PAYMENT.

SEC. 84. The board of commissioners of any county in this State, when petitioned so to do by one hundred freeholders of the county, may purchase any or all plank, gravel, macadamized and other toll roads in such county held or owned by any person, persons or corporation, and may pay for the same as hereinafter provided. Upon the filing of such petition, such board shall make an order directing that the road or roads named in such petition shall be appraised, and for that purpose shall appoint one appraiser, and request the judge of the circuit court of such county to appoint another, and the person, persons, company or corporation owning such road or roads, a third; whose duty it shall be to appraise such road, or roads, as hereinafter provided, and report such appraisement to such board of commissioners: Provided, however, That where such petition asks for the purchase of more than one road, the person, persons, company or corporation owning each road shall have the right to select one appraiser, who, with those selected by such board and judge, shall appraise the road owned by the person, persons or corporation appointing him. Such appraisers, in making an appraisement of any such road shall value it at its fair cash value, taking into consideration the manner of its construction, its condition as to repair and its net annual income, to be determined by the average amount thereof, for the five years next preceding such appraisement, as shown upon the books of such company, which average income they shall also report. After the return of such appraisement, which shall be filed with the county auditor, such auditor shall convene such board in special session, if it is not at the time in session, and shall notify the president of the company or the person or persons owning the road of the time of such meeting, and if such board and such owner or owners can agree upon terms, such board shall make an order upon its records for the purchase of such road or roads, setting forth the price and manner of payment; which price shall in no case exceed the appraised value thereof. Whenever an agreement to purchase any such toll road has been entered into as herein provided, the purchase money may be paid, in whole or in part, out of the general funds in the county treasury appropriated therefor, and if the funds in the treasury that can be used for such purpose are not sufficient, the bonds of the county may be issued therefor in the usual form, bearing not to exceed six per cent. interest, to an amount sufficient to perfect such purpose, and falling due at such times as shall be determined, not exceeding ten years; and the county treasurer shall sell [such] bonds, in the same manner as other county bonds are sold, to procure the amount required, or may deliver the same to the vendor of such road in payment thereof: Provided, however, That no money shall be paid, or bonds delivered to such vendor until a conveyance has been made of such toll road, including its franchises, to such county. And when so conveyed, such road shall thenceforth be free, and shall be kept in repair, as provided by law for the repair of other roads.

BOARD OF DIRECTORS—COUNTY COMMISSIONERS—DISTRICTS.

SEC. 85. By virtue of their office, the commissioners of each county in this State are hereby constituted a board of directors for all free gravel, macadam and turnpike roads in such county, under whose management and control all such roads are hereby exclusively placed. Such board shall purchase all material necessary to keep such roads in repair; such material to be purchased in accordance with the provisions of law relating to the purchase of supplies by boards of commissioners. The county auditor shall be clerk of such board and keep its records in a book provided for that purpose. It shall be the duty of such board of directors to divide the free gravel, macadam and turnpike roads of such county into three districts, each district to contain as nearly as practicable the same number of miles of such roads. Such directors shall by agreement assign one of their number to each of such districts, and such director shall have entire charge of the district so assigned him. Such director shall employ all labor and make all contracts necessary to keep the district under his control in repair, and also make such improvements in such roads, and make such contracts therefor as the board of directors may authorize. He shall oversee and superintend the labor employed and see that faithful work is done.

SUPERINTENDENTS—BONDS.

SEC. 86. Such board of directors may divide the free turnpikes in each of such districts, so as to appoint superintendents therein on the basis of one superintendent for not less than ten, nor more than fifteen miles of free gravel road therein: Provided, That where any district may contain, in the aggregate, less than ten miles of free gravel road the board may, in its discretion, appoint one superintendent thereof; such superintendents so appointed shall execute a bond to the State of Indiana for the use of the board of commissioners of such county in any sum not less than five hundred dollars, nor more than one thousand dollars, for the faithful performance of their duties as such superintendents; such bonds to be approved and the amount thereof fixed by such commissioners.

DUTIES OF SUPERINTENDENTS—PAY.

SEC. 87. Each superintendent, under order of the director in charge of his district, shall have charge of the repairs on his division of roads, and shall under such order have the employment of labor to keep such roads in repair; and he shall also oversee and superintend all labor employed and material used and see that proper material is furnished and that faithful work is done. He shall file necessary affidavits against persons violating the laws against heavy hauling on highways and see to the enforcement of all laws relating to the cutting of weeds along such highways. Each of such superintendents shall receive as compensation for his services not to exceed twenty-two and one-half cents per hour for his work done in person, and if he drives or uses his own team, with wagon or other implements, he shall receive not to exceed thirty cents per hour, but any such superintendent shall not use more than one team

of his own. Such boards of directors are authorized to adopt rules and regulations concerning the work on gravel and macadamized roads and turnpikes in their respective counties, not conflicting with any provisions herein, and all superintendents and men employed shall be governed thereby in all gravel road and turnpike work.

PREFERENCE TO LABORERS—PAY—PURCHASE OF MATERIALS.

SEC. 88. Such directors or superintendents in employing labor on roads shall give preference, when the same is equal in character and price with that to be had elsewhere, to the land-owners and laoorers along the line of such road; and such directors or superintendents shall each keep a complete and itemized time-book showing each laborer employed and all material purchased and placed on his said roads; which said time-book shall be produced to the board of directors for its inspection and that of the general public, when any such director or superintendent makes his report to such board; which said report shall be made in writing, quarterly, on the last day of the month of March, June, September and December of each year, and shall show the time and rate of compensation of each laborer, the dates thereof and the amount of any and all material and the purchase price of the same, placed on his said roads and when and where placed for the preceding quarter, and shall also show all sums paid on contracts, which contracts shall be filed with such report. Such report must be signed and sworn to; and, when filed, shall be preserved by the auditor, and be open to inspection by the general public at all times. Each of such commissioners shall receive for his annual services as such gravel road director, ten cents for each mile of gravel road or turnpike road in his county, which compensation shall be paid quarterly. All such fees are to be paid out of the free gravel road repair fund.

MATERIALS FOR REPAIRS—SUPERINTENDENT.

SEC. 89. When the director or superintendent of any free gravel road or turnpike shall file his verified petition before the board of commissioners of his county at any regular session thereof, setting forth that in his opinion the interests of any such free gravel roads or turnpikes require an entry upon any land in such county to make drains or procure gravel, stone, timber or any other material necessary for the repair of such free gravel road or turnpike and giving a description of the land to be entered upon, together with the name of the owner, and the probable amount of drainage or material required, together with the probable cost of the same; such board after having satisfactory proof that due notice, in writing, of the presenting of such petition has been served upon such land owner or the occupant of such land for at least ten days before the presenting of such petition, shall thereupon appoint three disinterested freeholders of the county, who, after being duly sworn, shall proceed upon such land and hear evidence and view the premises, and make written report, under oath, to such board at its next regular session, showing the amount of damages such land owner will sustain by reason of the appropriation of such drainage or materials for such purpose; and thereupon

such board shall allow such amount specified by such viewers' report and cause the auditor to issue his warrant for such sum to such land owner; and such board shall also cause the auditor to issue his warrant for the reasonable charge of such viewers in doing such work, which damages and expenses shall be paid by such county out of the gravel road repair fund, and thereupon such director or superintendent shall have the right to immediate entry upon such land to make such drainage and take and use such materials for such purpose. Such land owner if he deem such amount so allowed inadequate for the payment of his said damages, shall have the right of an appeal to the circuit court from such order allowing and assessing such damages, in like manner as other appeals are now allowed to be taken from the board of commissioners to the circuit court.

GRAVEL ROAD FUND—TAX LEVY—COMPENSATIONS.

SEC. 90. In any county in which free gravel, macadamized or turnpike roads are maintained under the commissioners of such county, acting as a board of directors of such road, as provided in the last preceding five sections, the said board of commissioners shall annually levy upon all taxable property of such county such sum as such commissioners shall deem necessary for the repairs of such roads, not to exceed one cent upon each one hundred dollars of such taxable property for every ten miles of free gravel, macadamized or turnpike roads completed in such county, the proceeds of such levy to constitute a gravel road fund in the county treasury to be paid out only upon the order of the county auditor issued upon the certificate of the board of directors of such gravel, macadamized and turnpike roads. The compensation of such gravel road directors for their services as such shall be three dollars per day for the time actually served, which shall be in addition to the ten cents per mile hereinbefore provided for. The compensation of each superintendent, or director acting as such, shall be subject to the agreement of the board of directors, not to exceed two dollars per day. All such compensation is to be paid out of the gravel road fund.

REPAIR OF HIGHWAYS.

SUPERVISORS—ELECTION—PAY—DISTRICTS.

SEC. 91. The qualified voters in each road district of the several townships of the several counties in the State shall, on the second Saturday after the first Monday in December, 1905, and every two years thereafter, elect a supervisor who shall hold his office for the term of two years and until his successor is elected and qualified. Road districts shall not be held to include any part or parts of cities or incorporated towns that may be in the township in which such road districts are located. Each supervisor shall receive the sum of one dollar and fifty cents per day for his services actually performed, not exceeding forty days in any one year to be paid out of the township treasury, but before receiving the same he shall file his sworn statement with the trustee of the township, which statement shall specify the days on which such services were

performed: Provided, Such supervisor shall not be entitled to charge or receive any compensation whatever for a number of days equal to the number required of other persons of his road district liable to work on highways. Upon the taking effect of this act, if deemed necessary by any trustee of any township, such trustee shall divide his township into not more than four nor less than two road districts as nearly equal in number of miles of road as practicable and appoint supervisors therefor, to hold their offices until their successors are elected and qualified, and if any additional road districts shall be created he shall appoint supervisors thereof to hold their offices until their successors shall be elected and qualified as herein provided; and whenever such trustee shall deem it necessary he may make any change in such road districts that may subserve public interests; Provided, That any change of the existing boundaries of road districts shall not be made except upon petition of six freeholders living in the immediate vicinity of the change proposed to be made. On dividing his township into road districts, or where any change is made therein, such trustee shall record a plat thereof in the highway record of his township, which shall show the roads and parts of roads belonging to each road district. Each supervisor shall at the time of his election or appointment be a qualified voter of the road district for which he is elected or appointed.

NOTICE OF ELECTION—HOW CONDUCTED.

SEC. 92. The township trustee of each township shall on or before the first Monday in December, 1905, and every two years thereafter, post up or cause to be posted, in at least two public places in each road district of his township, written or printed notices of an election of supervisor of such road district, giving therein the place, day and hour at which such election is to be held. The day and hour of such election shall be the same in each road district of the township. The place of such election shall, if practicable, be a schoolhouse, located in the road district. The township trustee shall act as inspector of the election in the road district in or nearest to which he resides, and shall name from among the qualified voters present two clerks, who shall, if possible, not both be of the same political party. Such clerks, with the trustee, shall form an election board to judge of the qualifications of voters, and shall collect or receive and shall count the ballots cast. If one or more members of the election board, or one or more freeholders among the qualified voters present shall challenge any one offering to vote, and declare under oath that such an one is not entitled to vote, giving reasons for such declaration, then, after the one offering to vote and challenged as aforesaid shall have been given an opportunity to reply and to declare under oath his qualifications, if such one or more members of such election board or such one or more freeholders among the qualified voters present persist in their challenge and declarations, the one thus challenged shall not be allowed to vote unless a freeholder among the qualified voters present shall declare under oath that such challenged voter is entitled to vote in that road district at that election. For the election of supervisor in each road district of his township, other than the one in or nearest to which he resides, the trustee

shall name an inspector of election, and such inspector shall name two clerks, of different political parties, if possible, from among the qualified voters present. Such inspector shall be a freeholder in the road district in which the election is held. The inspector and the two clerks shall constitute an election board to judge, as heretofore provided, of the qualifications of voters, and to receive or collect and to count the ballots cast. Such inspector or trustee shall be authorized to administer all necessary oaths in relation to such election. The inspector and clerks provided for in this act shall serve without pay, but the township trustee shall be entitled to his regular pay for one day for the day on which the notices aforesaid are posted up and for one day for the day on which he files reports of election of supervisors with the auditor of the county. The trustee shall provide paper for ballots and for the clerks in their count of such ballots. The trustee or inspector shall be present promptly at the place and hour named in the notice of election, and if the said trustee or inspector shall not appear within fifteen minutes after the time set, then the qualified voters present shall select a freeholder from their number as inspector. The polls shall close two hours after the trustee or inspector shall have announced that the polls are open, if all voters present have voted, or have been given an opportunity to vote, provided that the election board may close the polls sooner if all voters present have voted or have been given an opportunity to vote, and no vote has been cast for ten minutes. Immediately upon the announcement that the polls are closed, the election board shall proceed to count the ballots, and during the count all voters shall be excluded from the room in which the count is made, excepting only the election board and two watchers, who may be named, one by each of the clerks. The person receiving the highest number of votes cast shall be deemed to be elected. Only those ballots shall be counted which contain the name of but one person, and mistakes in spelling or in initials shall not prevent the ballot from being counted where the intent of the voter is evident; all counted or uncounted ballots shall be preserved under seal by the trustee until June following the day of election. Ballots may be either written or printed. When the count is completed the trustee or inspector shall at once announce the result and the trustee shall issue a certificate to the person so elected. The inspector of each district other than that of which the township trustee is inspector shall file with such trustee the report of election in his district, together with all papers and ballots. The trustee shall within three days file with the auditor of such county a report of all elections of supervisors held in such trustee's township, which report shall be certified to, in the case of each road district, by the members of the election board in such district.

VACANCIES—HOW FILLED—EXEMPTION.

SEC. 93. When there shall be a failure to elect a supervisor for any district, and also in case a vacancy shall occur in such office for any cause, the trustee of the township in which such district is situated, as soon as he is informed of such failure or vacancy, shall appoint a supervisor who shall hold his office until the next biennial election; and when an appointment of supervisor is made by such trustee he shall make out

a certificate of such appointment and deliver the same, within three days after such appointment, to the person so appointed. Any person may be exempt from serving as such supervisor by paying into the township treasury the sum of six dollars, and in such case, the vacancy shall be filled as hereinbefore provided; but no person shall be compelled to serve oftener than one term in six years.

OATH AND BOND—DUTIES—VACANCY.

SEC. 94. Such supervisor shall take an oath, before entering upon the discharge of his duties, for the faithful performance thereof, and give a bond with surety, to be approved by the township trustee and conditioned for the faithful discharge of his duties, in a sum not less than two hundred dollars, which bond shall be deposited with the township trustee. He shall carry into effect all orders of the trustee of the township in which the roads district is situated, touching the highways and bridges therein, and keep the same in good repair. He shall also call out all persons in such district liable to work on highways therein, superintend the labor thereon, see that the same is faithfully performed and report to the trustee all fines and commutation moneys due such district and the same shall be collected by such trustee: Provided, That if any person elected or appointed supervisor shall be unable to give such bond, such inability shall be a defense to the collection of the forfeiture provided for in the preceding section, and the township trustee shall appoint some one else as supervisor.

WHO REQUIRED TO WORK—TIME.

SEC. 95. Such supervisor shall call out all able-bodied male persons, except insane, idiotic, deaf and dumb, and blind persons, who are residents of such district and are over the age of twenty-one years, and under fifty years of age, and not exempt from such labor, during not less than two nor more than four days of each year, between the first day of May and the first day of December of each year. The supervisor shall require such persons to work on the highways of such district eight hours each day, and to furnish in such labor any tool that the supervisor may direct, if the demand therefor be a reasonable one. Any person able to perform an ordinary day's labor shall be deemed able-bodied, within the meaning of this act, although the person may be in some respects disabled: Provided, That no person who served in the army or navy of the United States during the war for the Union or the war with Spain or in the Philippine Islands, and who was honorably discharged therefrom, shall be required to labor on the public highways.

TEAMS—CREDITS.

SEC. 96. Such supervisor may require any person liable to work on such highways who is the owner of an ox, mule or horse team, road scraper, road scoop, cart or wagon to furnish the same, and a driver, in such labor on such highways, and such person shall receive credit for two days' labor for each day's service by such driver and team, and shall be given a receipt by such supervisor accordingly.

FALSE CREDITS—PENALTY.

SEC. 97. Any road supervisor who shall issue and deliver to any person his receipt, giving credit for work done on highways in his district, when such person to whom, or for whom such receipt is issued, has not actually worked or caused work to be done for the full time that such receipt gives credit for at the rate of eight hours for one day's work or has not paid the commutation money as provided by law, shall be deemed guilty of a misdemeanor, and, on conviction, shall be fined not less than ten dollars nor more than fifty dollars for every such receipt so issued.

NOTICE OF WORK.

SEC. 98. Such supervisor shall notify each person in his road district liable to work on the highways thereof of the time and place of working on such highways, at least three days prior to the time designated for such work. Such notice may be verbal or written, and if written shall be left at the residence of the person so notified.

EXEMPTION FROM LABOR.

SEC. 99. On application to the township trustee any person liable to work on the highways may be exempt therefrom if it be shown that he is unable from bodily infirmities to work thereon and that he is too poor to pay the commutation therefor; also any person who is a bona fide member of a legally organized fire company, located in any city or town in this State. And in such cases the township trustee shall execute to such person a certificate, which shall, on being presented to the supervisor, entitle him to such exemption.

COMMUTATION MONEY—USE.

SEC. 100. Any person liable to work on the highways may be exempt therefrom by paying to the supervisor of his road district one dollar and fifty cents for each day he is liable to work thereon, and in that case he shall receive a receipt therefor from the supervisor. Such supervisor shall be authorized to employ some person or persons to work out such money, at the rate of one dollar and fifty cents per day, on the roads of his district; or, failing so to do, he shall pay over all such money into the township treasury, for the benefit of the road district.

FAILURE TO WORK—PENALTY.

SEC. 101. Every supervisor, within ten days after warning out the hands liable to work in his district, shall notify the trustee, who shall bring suit before any justice of the peace of the township in which such district is situated, and in the name of such township, against such persons as fail to work or pay over the commutation money therefor; and in such suit it shall be necessary to file only an account stating the number of days which each of such persons so failed to work or pay for, and

charging one dollar and fifty cents per day each therefor; and in case of a recovery against any such defendant, the judgment shall be rendered for one dollar and fifty cents for every day the defendant so failed, and costs of suit, and no stay of execution or benefit of exemption, valuation or appraisement laws shall be allowed on such judgment. In case any such trustee shall fail to bring suit, after having been so notified by such supervisor, he shall forfeit and pay the sum of ten dollars, to be recovered in an action brought by the prosecuting attorney, before any justice of the peace of the township, in the name thereof; and all money so recovered under the provisions of this section shall be received and expended under the direction of the township trustee by the proper supervisor in the improvement of the highways of his district: Provided, That any such trustee shall not be required to bring suit against any person from whom there is no probability of collecting, or who, at the time of working, shall be sick or otherwise unable to labor. If such person so temporarily sick or disabled be liable to pay commutation, he shall so pay, or the trustee shall sue therefor within sixty days. No person able to pay commutation shall be exempt on account of bodily disability.

SUBSTITUTES.

SEC. 102. Any person liable to perform labor on the public highways, when notified for such purpose, may appear in person or by an able-bodied substitute, and the person or substitute so appearing shall actually work eight hours each day, under penalties of twenty-five cents for every hour such person or substitute shall be in default, to be deducted by the supervisors from the price of the day's labor.

IDLING—PENALTY.

SEC. 103. If any such person or his substitute, after appearing, shall remain idle or not work faithfully, or shall hinder others from working, such offender shall, for every such offense, forfeit the sum of one dollar and fifty cents, to be collected from such person as other fines and forfeitures herein specified, and such person or his substitute shall be discharged by the supervisor without credit for any part of the work he may have done.

REPAIRS—HOW MADE.

SEC. 104. Such supervisor, within ten days after the receipt of any money which he is not required to pay over to the township trustee, shall proceed to employ laborers to repair the highways in his district, but shall not pay more to such laborers than is customary in his district for similar services, and such supervisor shall superintend such repairs; but in no case shall such supervisor neglect to repair such highways, and if such labor shall be insufficient therefor, he shall call out the hands in his district to complete such repairing. If any person so called out shall refuse to work, he shall be liable to pay the commutation money therefor, and it shall be the duty of the trustee to bring suit for the same as provided in section one hundred and one of this act.

EXTRA LABOR—CREDIT.

SEC. 105. When such extra labor provided for in the next preceding section shall not require all the hands in the district, or an equal amount of labor from each, the supervisor may assess the same upon such hands as he may deem sufficient, and for the excess of work performed by any one over the average amount performed by all he shall give to each person performing such excess a certificate of the amount thereof, which shall be credited to the holder on account of any subsequent labor to be done by him on the highways in his district.

ENTRY ON LAND—DAMAGES ASSESSED—APPEAL.

SEC. 106. The supervisor, or any other person by his order, may enter upon any land adjoining or near to any highway in his district, and thereupon construct such ditches, drains and dams, and dig and remove such gravel, earth, sand or stone, or cut and remove such wood or trees as may be necessary for the proper construction, repair or preservation of such highways; and the supervisor, together with two disinterested persons, shall proceed at once to the locality and assess such damages in favor of the owner of the lands thereof, as in their judgment seem right and proper, and report the same under oath, within ten days after such assessment, to the trustee, having first given notice thereof to the party damaged, and such trustee shall pay the damages assessed out of the township treasury. The oath to such appraisers may be administered by the supervisor, and the oath to the supervisor may be administered by the trustee. No person's land shall be entered when material can be found on the roadway, or convenient in the district on the roadways thereof, nor when drainage can be made on the roadway, at a cost not exceeding the cost and damages of entering upon private lands. In all cases contemplated in this section, demand shall first be made of the owner of the land before entering thereon or taking material. If he assent, he may point out the material and the location from which it is to be taken, and, if accessible and fit for the purpose intended, the material shall be there taken. If consent be refused by the owner, the supervisor shall notify such owner of his intention to so enter, for what purpose and for what time, and point out the land to be occupied, or the material to be taken. In all assessments of damages the owner shall be notified, and have leave to select one appraiser, and shall have notice of the time and place of the meeting of the appraisers, and privilege to offer evidence as to damages at the time of the assessment by the appraisers: Provided, also, That any person aggrieved may appeal from the action of the appraisers to any justice of the peace of the township, by giving notice in writing to the road supervisor. Such notice must be given within ten days after final action by the appraisers, and such person shall give bond within thirty days after final action by the appraisers. Such bond shall be payable to the trustee, and shall be filed with and approved by the appraisers, and thereupon the papers shall be delivered to the justice of the peace; and such appeal shall be determined as other questions are determined in civil cases before justices of the peace.

OBSTRUCTION—REMOVAL.

SEC. 107. When a public highway, running through or bordering upon a tract of real estate, shall become obstructed, the owner or occupant of such land shall remove such obstruction as soon as the same shall come to his knowledge, for which the proper supervisor shall allow him a reasonable credit on his liability to work on the highways, unless the obstruction be caused by the act of such owner or occupant, in which case he will be required to remove the same without any credit.

TREES—OWNERSHIP.

SEC. 108. All trees standing or lying on the land over which any highway shall be laid out, which it shall be necessary to remove in the opening of such highway, shall belong to the owner of such land, if he shall remove the same before the supervisor is required to open such highway; but all such trees and down timber, or other material found on such premises, may be taken and used by the proper supervisor for the construction or repair of the highway or of any bridge thereon.

BRIDGE OR CULVERT.

SEC. 109. If the township trustee of the township where any proposed bridge or culvert is to be located or repaired shall notify the board of commissioners of his county of the necessity of such location or repair, and if in the opinion of the commissioners the public convenience shall require the building or repairing thereof, they shall cause surveys and estimates to be made and provide for the erection of the same: Provided, That if the board of commissioners shall not deem such bridge or culvert of sufficient importance to justify an appropriation from the county treasury for the building or repair thereof, the trustee of the township in which is located such bridge or culvert may appropriate any part of the road fund in the township treasury for that purpose, if he shall deem it right and expedient to do so.

LEVY OF ROAD TAX—HOW PAID.

SEC. 110. The township advisory board, on an estimate made by the township trustee, shall levy annually on or before the first Tuesday in June a road tax of not more than thirty cents on one hundred dollars to be levied according to the amount of real and personal property owned in such township, outside of the corporate cities and towns subject to taxation for road purposes, to be collected as other taxes are collected, except all road taxes are to be collected with the first yearly installment of taxes: Provided, however, That the taxes so assessed on real estate shall be worked out, as near as practicable, in the road district in which such real estate lies, and the taxes assessed on the personal property in the district where the owner resides, at the rate of one dollar and fifty cents per day for each man. Such supervisor may require any person liable to work on such highways who is the owner of an ox, mule or horse, team and plow, road scraper, road scoop, cart or wagon to furnish the same.

and a driver, in such labor upon such highways, and such person shall receive a credit for two days labor therefor, and shall be receipted by such supervisor accordingly: Provided, further, That the township trustee may, with the consent of the township advisory board, levy an additional tax, not to exceed ten cents on one hundred dollars' valuation, to be paid into the county treasury with the first installment of taxes and to be paid by the treasurer to the township trustee, to be expended for the construction and repair of bridges and culverts and for other road purposes. It shall be the duty of the county auditor to procure and deliver each year, on or before the 10th of September to the proper township trustee, a list of all road taxes assessed on each individual in his township, and the receipt of the supervisor of the proper district for the amount worked out by any taxpayer shall be taken by the treasurer of the county in payment of so much of said taxes, if presented during the year in which the labor has been performed, or the year following upon the performance of said labor. No supervisor shall issue receipt for work performed by himself, except for his own road tax, and no county treasurer shall receive the certificate of any supervisor except in payment of taxes on which the work shall be performed: And, provided further, That the taxes so assessed on the real estate and personal property shall be worked out, as near as practicable, in the road district in which said real estate is situate, and the personal property under the supervision of the supervisor of the district where said labor is performed, in the district in which the owner resides, upon three days' notice of the time and place such labor is to be performed: Provided, further, That the road tax assessed on real and personal property shall be worked out on or before the first day of December of the year for which the levy was made. All credits allowed by county treasurers for road taxes worked out, upon settlement with the township trustee, to be properly distributed and charged, and road supervisors are required to make out and deliver to the township trustee, on or before the first day of December in each year, a statement containing a true list of persons of their respective road districts having worked out their road tax, or any part thereof, during the year, together with the amount worked out by each person.

EXPENDITURE OF ROAD TAX.

SEC. 111. The township trustee shall order the expenditure of the funds derived from the tax provided for in the last section in the improvement of the highways of his township under such regulations as he may deem expedient for the public interest, and for this purpose shall pay such sums as may be necessary, on the order of the supervisors of the township, for work done by them under his direction. Such order or orders drawn upon the trustee shall distinctly state the services performed by the person or persons to whom the order is given.

LETTING WORK BY CONTRACT.

SEC. 112. Such trustee may let out the work contemplated in the last preceding section to the lowest responsible bidder, and for this purpose he may cause notices to be posted up in three of the most public places in

the township, that proposals will be received under such regulations as he may prescribe, at a time and place to be by him designated, for the improvement or repair of all the highways and bridges, or any part thereof, in such township; and in all such cases such trustee shall adopt such regulations as to the extent of the improvements or repairs, terms of payments, superintendence of the work, and the time of commencement and completion thereof, as he may deem proper. Payments on such contracts, according to the terms thereof, shall be made by the trustee out of the road or bridge funds in his hands.

INJURING OR OBSTRUCTING HIGHWAY—PENALTY.

SEC. 113. Any person who shall injure any dam, drain, embankment, ditch or other construction made for the protection of any highway or bridge, or who shall wilfully destroy any guide-post, or deface any inscription or device thereon, or who shall unnecessarily, and to the hindrance of passengers, obstruct any highway or bridge, and who shall, when driving any vehicle, fail to pass to the right when meeting another vehicle, so as to allow it to pass without injury, for every such offense, shall forfeit the sum of five dollars, to be recovered by the trustee in the name of the township before a justice of the peace of the county; and for every day such obstruction is continued the same sum shall be recovered. In all such cases such trustee, within three days after receiving information of any such offense, shall commence such suit, and the sum recovered thereon shall be used for the benefit of the highways of such township. In case of a recovery in any such action the justice of the peace shall tax, as costs, the sum of five dollars as attorney's fees for plaintiff's attorney.

SUIT BY SUCCESSOR.

SEC. 114. All such suits commenced by one trustee may be continued by his successor in office, and no costs shall be taxed against him therein. Any supervisor who shall fail to use due diligence in keeping the highways of his district in good repair, under the regulations herein prescribed; or who shall fail to call out the hands of his district to work on the highways thereof the number of days herein prescribed, unless the tax assessed for such repair of such highway is sufficient; shall, for every such offense, forfeit the sum of ten dollars, to be recovered before any justice of the peace of the county, in the name of the township, by the trustee of such township; and all sums so recovered shall be for the benefit of the district for which such supervisor was elected or appointed, and such trustee shall bring suit within three days after receiving information of any such failure of duty by such supervisor.

DUTIES CONTINUOUS—TOOLS.

SEC. 115. Every supervisor shall hand over all books, papers and moneys, as well as all tools in his possession, to his successor in office when called for. Township trustees shall procure, with available road fund in their hands, such tools and implements as may be necessary for road districts.

ORDER OF WORK—DONATION

SEC. 116. In determining upon the amount and character of work which shall first be done on any highway, or part thereof, the township trustee shall take into consideration the importance of the highway to the traveling public, and its convenience to gravel, stone or other material to be used in its construction. Whenever the citizens interested in the permanent improvement of any highway of public importance, shall, by donation, properly ditch, drain, gravel, embank or otherwise improve any such highway, such trustee may contribute and perform work thereon equal in value to such donation, if he have the means in his hands to do so: Provided, moreover, That every township trustee shall set aside not less than five per cent. of the road funds received by him each year as an emergency fund, to be used in keeping in repair all highways in his township along or on which United States rural free delivery mail routes have been or may hereafter be established and maintained; and it shall be the duty of every such trustee, and of every road supervisor, to give the preference to such highways in keeping the same in repair. Such highways shall be kept properly drained and free from all obstructions, including snow-drifts, so as to be at all times in good condition for ordinary travel.

OATHS.

SEC. 117. Each township [trustee] is empowered to administer oath in all cases touching the prosecution of the business of the township of which he is trustee.

DISBURSEMENTS OF ROAD FUND.

SEC. 118. All road money on hand or that may hereafter be paid to the county treasurer under the provisions of this or of any previous act, shall be paid to the proper township trustee, and be expended by him as other road funds are required by this act.

SUPERVISOR'S REPORT.

SEC. 119. Each supervisor of each road district shall, on or before the first day of December in each year, make a full and succinct report, under oath, of his proceedings, showing the names of all persons liable to perform, or who have performed, labor on the roads in his district; the amount of commutation money received, from whom received, and the amount of money received from any and all sources whatever, and how the same has been expended; and shall pay such balance to and file such report with the trustee of his township on that day.

REPORTS AUDITED.

SEC. 120. Such township trustee shall audit the reports referred to in the last section, and enforce the payment of any such balance, and compel such report by suit.

RESPONSIBILITY FOR TOOLS.

SEC. 121. Every road supervisor shall be responsible for the care and safe-keeping of all the tools belonging to his road district, and on going out of office shall report the number and kind of tools in his hands to the trustee of his township, under oath; and such trustee shall charge each supervisor, on coming into office, with the whole amount of tools in his district, as shown by the statement of his predecessor in office. Such supervisor shall be liable for any loss of, or damage to the tools belonging to his road district, occasioned by his neglect, to be recovered in the name of his township, upon complaint of the trustee of such township before any justice of the peace therein.

ROADS ON DIVISION LINES.

SEC. 122. All roads running on township, county or road district lines are assigned for construction and repairs as follows: On roads running north and south, the north half is assigned to the township or townships and district or districts on the west side of such line, and the south half is assigned to the township or townships and district or districts on the east side of such lines; and on roads running east and west, the west half is assigned to the township or townships and district or districts on the south side of such line, and the east half to the township or townships and district or districts on the north side of such line. And the highways so assigned shall be under the control of and be kept in order by the township trustee of the township to which they are assigned. All roads running on lines dividing this State from other States shall be worked in conjunction with such other State, and shall be assigned for construction and repairs in the same manner as above provided in cases where roads run on township or county lines, as far as applicable.

APPEAL TO CIRCUIT COURT—EFFECT OF ACT.

SEC. 123. Except as otherwise provided in this act, any person aggrieved by any decision of the board of commissioners of any county, in any proceeding in relation to highways, may appeal therefrom within thirty days thereafter to the circuit court of such county, by filing a bond, with surety and penalty, to be approved by the auditor of such county, conditioned for the due prosecution of such appeal, and the payment of costs, if costs be adjudged against him; and in case proceedings shall be had in more than one county, the appeal shall be to the circuit court of the county in which the proceedings were first instituted, and the auditor of each county, on being notified of such appeal by the auditor of the county in which the appeal is taken, shall transmit to the clerk of the court to which the appeal is taken a transcript of all the proceedings in such county; and upon the determination of such appeal such clerk shall give notice thereof to the auditors of all the counties interested. Such appeal shall be tried de novo, and may be had as to any issue [tried], or that might have been tried, before the county board; but every report made to the board by viewers or reviewers or by any committee, body or officer,

under the provisions of this act, shall be considered in evidence on such appeal. The court may make final determination of the cause so appealed, or may refer the case back to the county board or boards, with directions how to proceed. This act shall not have the effect to release any penalty, forfeiture or liability incurred under any former statute, nor shall it affect any pending litigation or proceedings, but the same shall be concluded and be effective in all respects as if this act had not been passed.

REPORT OF STATE INSPECTOR OF MINES.

OFFICE OF INSPECTOR OF MINES,
INDIANAPOLIS, INDIANA, February 12, 1906.

Prof. W. S. Blatchley, State Geologist:

DEAR SIR—I have the honor to submit to you herewith my seventh annual report as Inspector of Mines, covering the calendar year of 1905, and being the Twenty-seventh Annual Report of this Department and the fifteenth made to the Department of Geology and Natural Resources.

I trust it will receive your approval and be found worthy of consideration by the public.

JAMES EPPERSON,
Inspector of Mines.

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ANNUAL REPORT OF THE INSPECTOR OF MINES FOR INDIANA.

The subject-matter of this report is treated under the same several captions as in preceding reports, viz., Production of Coal, Condition of Coal Trade, Condition of Labor, Statistical, and Mine Accidents.

While following the same general lines as in former reports we have endeavored to improve on the different subjects reported, making the information more complete and reliable and of greater interest to the general public. There have also been included in this report the following new tables, which we think contain information desirable especially to those interested in mines and mining: A comparative average wage table has been added, a table showing the per cent. gain or loss in tons of coal produced, number of employes and wages paid from 1900 to 1905 inclusive. Tables of Mining Machinery, Table of Mines Suspending operations for a period of thirty days or more, a table showing the Geological Number and the Number of Tons of Coal Mined from each seam of coal in the State. The following summary contains most of the important totals for the year.

SUMMARY.

Number of counties having shipping mines	14
Number of companies operating mines	95
Number of new companies organized	6
Number of new mines opened	14
Number of mines changing hands	81
Number of machine mines	76
Number of pick or hand mines	114
Total number of mines working more than ten men	208
Number of mines abandoned	16
Number of pick miners employed	8,760
Number of machine runners and helpers employed	876
Number of loaders employed	3,693
Number of inside day and monthly men employed	1,657
Total number of all employes	18,609
Number of mules used	1,449
Number of electric chain machines	374

Number of compressed air punching machines	158
Total number of mining machines	432
Number of electric traction mine motors	23
Number of third-rail electric mine motors	11
Total number of motors	34
Number of dynamo engines	85
Number of dynamos	85
Number of compressors	25
Number of steam boilers	385
Number of hoisting engines	190
Number of automatic cages	244
Number of shaker screens	42
Number of box car loaders	26
Number of coal washers	1
Total estimated value represented by tables of machinery	$1,531,235 00
Total number of days mines have been operated	29,277
Total tons hand-mined block coal	583,662
Total tons machine-mined block coal	75,073
Total tons of block coal	658,735
Total tons bituminous hand-mined coal	6,275,540
Total tons bituminous machine-mined coal	4,061,697
Total tons bituminous coal	10,337,237
Total tons hand-mined coal	6,859,202
Total tons machine-mined coal	4,136,770
Total tons of coal produced	10,995,972
Total tons of coal consumed in Indiana	5,786,035
Total tons coal shipped outside the State	5,209,937
Total wages paid to miners	$6,174,749 73
Total wages paid to inside day and monthly men	2,100,474 38
Total wages paid to outside day and monthly men	1,078,670 44
Total wages paid to all employes	9,353,894 55
Amount expended on improvements	149,838 12
Total number of fatalities	47
Total number of serious accidents	103
Total number of minor accidents	101
Total number of accidents to employes	251

TABLE

Showing by Months and by Counties the Number of Tons Mined and Wages Paid to Employes for the Year 1905 at Mines Employing More than Ten Men.

MONTHS.	CLAY COUNTY.		DAVIESS COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	65,196	$79,567 96	9,777	$10,704 14
February	65,111	70,988 22	8,522	9,343 33
March	44,518	59,209 46	6,665	7,470 77
April	39,306	48,823 40	6,186	6,842 33
May	37,658	44,756 71	7,096	7,196 37
June	47,611	53,835 33	5,513	6,518 49
July	62,759	71,847 23	2,899	5,537 90
August	71,934	84,496 97	2,322	5,123 07
September	77,200	82,928 10	4,211	7,575 48
October	85,106	96,656 88	5,498	7,970 96
November	93,402	95,405 03	8,623	10,434 54
December	126,059	118,942 87	9,346	10,877 86
Total	815,860	$907,458 16	76,653	$94,795 24

	FOUNTAIN COUNTY.		GIBSON COUNTY.	
January	4,604	$4,658 51	13,167	$10,963 56
February	4,963	4,965 97	10,828	9,726 25
March	5,349	5,355 27	8,371	8,384 67
April	6,042	5,451 87	5,323	6,807 44
May	5,542	5,118 67	2,855	3,136 21
June	6,786	6,323 65	3,714	3,523 14
July	5,367	5,561 76	6,024	5,394 74
August	6,803	6,778 06	5,965	5,583 70
September	6,664	6,499 36	8,086	6,896 69
October	5,762	5,732 53	12,477	10,705 34
November	6,841	6,094 50	11,920	10,618 62
December	5,812	5,870 39	12,117	10,978 88
Total	70,535	$68,410 54	100,847	$92,719 24

	GREENE COUNTY.		KNOX COUNTY.	
January	231,705	$193,557 06	18,207	$14,264 24
February	218,164	178,014 11	15,630	13,243 79
March	189,007	149,480 55	8,909	7,705 91
April	124,155	104,115 60	6,743	5,589 54
May	142,019	117,332 76	11,206	8,660 15
June	152,655	125,067 88	15,826	14,011 74
July	130,668	110,782 24	20,100	17,026 14
August	155,251	130,401 46	19,300	16,302 08
September	189,488	149,971 19	24,805	21,871 51
October	225,262	176,237 37	23,939	22,227 44
November	232,116	185,771 32	28,166	23,323 15
December	255,700	200,413 01	31,133	25,455 01
Total	2,246,190	$1,821,144 55	223,964	$189,680 70

MONTHS.	PARKE COUNTY.		PERRY COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	64,673	$70,376 61	303	$405 45
February	67,859	73,910 04	71	158 37
March	52,396	48,200 50	775	777 82
April	44,165	40,920 13	865	747 02
May	39,646	36,815 97	1,012	966 97
June	45,480	47,024 77	974	933 66
July	61,936	67,432 69	786	721 77
August	68,588	83,073 37	702	660 99
September	62,969	69,566 71	456	502 26
October	75,612	80,656 71	684	696 60
November	76,584	75,821 49	528	599 71
December	80,105	72,896 20	739	734 45
Total	741,013	$766,695 19	7,895	$7,905 07

	PIKE COUNTY.		SULLIVAN COUNTY.	
January	31,879	$25,847 66	212,353	$171,489 38
February	33,624	26,386 11	177,681	135,944 88
March	26,679	22,060 29	182,816	147,368 41
April	20,994	17,602 74	142,393	118,051 47
May	20,932	17,477 49	145,974	118,150 67
June	25,022	20,261 54	146,829	125,548 17
July	30,976	25,933 15	173,143	147,714 29
August	28,476	24,375 02	154,622	142,690 45
September	40,015	31,912 58	195,541	159,635 96
October	45,280	35,338 89	227,448	166,877 18
November	41,833	33,195 40	199,504	151,687 25
December	43,135	33,520 74	437,614	359,795 82
Total	388,845	$313,911 61	2,395,918	$1,944,953 92

	VANDERBURGH COUNTY.		VERMILLION COUNTY.	
January	31,092	$26,149 71	87,901	$74,146 30
February	32,379	26,921 67	74,344	64,986 37
March	19,143	16,844 08	96,802	79,346 16
April	15,906	14,252 94	112,956	93,346 65
May	12,778	12,809 11	134,035	103,796 60
June	13,995	15,598 08	132,668	108,377 27
July	18,211	17,558 77	129,170	101,066 13
August	22,202	21,082 42	110,405	87,668 04
September	28,691	25,268 02	113,550	91,093 63
October	36,326	30,719 11	116,539	94,430 62
November	39,539	32,294 98	128,716	102,169 34
December	37,519	32,080 21	144,160	108,375 18
Total	307,781	$271,579 10	1,381,246	$1,108,802 29

	VIGO COUNTY.		WARRICK COUNTY.	
January	150,067	$129,980 20	37,149	$23,505 65
February	152,280	124,125 70	38,274	23,039 78
March	153,417	124,851 10	26,637	16,595 78
April	151,494	120,170 79	20,413	13,071 76
May	154,470	132,441 55	20,256	12,434 37
June	139,166	120,601 87	23,543	12,967 68
July	141,846	121,505 73	22,930	9,794 36
August	139,336	117,091 23	23,947	14,314 84
September	161,465	132,789 08	23,202	13,802 43
October	155,489	129,360 98	31,710	19,297 31
November	193,333	151,313 55	35,570	21,046 49
December	203,254	159,743 65	36,978	21,903 06
Total	1,898,617	$1,563,975 43	340,608	$201,863 51

PRODUCTION OF COAL AND MINING CONDITIONS.

A review of the coal industry in Indiana for the year 1905 discloses it to be one of marked features. During the spring and summer months the business was apparently in a depressed condition. A majority of the mines throughout the State were running less than half time, while a number were closed entirely for indifferent periods. The selling price of coal was also very low during these months, ranging from 85 cents to $1.25 per ton, mine run, at the mine. Business, however, was much better commencing in September, and continued so throughout the remainder of the year. The selling price of coal was also much better during that period, ranging from $1.25 to $1.50 per ton, mine run, at the mines. Notwithstanding the idle time above mentioned, the total production for the year was 10,995,972 tons, an increase of 1,003,419 tons, or a fraction over 10 per cent. greater than any preceding year in the history of the State.

The aggregate wages paid to mine employes in 1905 was $9,353,894.55, an increase of $188,490.17, or a fraction over 2 per cent. greater than in any preceding year. The total number of employes for 1905 was 18,609, an increase of 771 employes, or a fraction over 4 3-10 per cent. greater than in any previous year. Considering the time the mines were idle, the above increase in production, wages paid and number of employes may be surprising to some, yet the following reasons should explain the situation thoroughly, viz.: In 1904, 42 new mines were opened, a majority of which had only reached their full producing capacity at the close of the year. All of these new mines, of course, secured a proportionate share of the trade. One other reason is the fact that, while some of the mines were closed indefinitely by the large coal companies who purchased them, yet the trade thus apparently lost was concentrated at other mines owned by them. This was especially true in Greene, Sullivan, Vermillion and Vigo counties. A fair illustration can be had from the Southern Indiana Coal Company. While their Hoosier No. 2 mine was practically closed the entire year, yet their Lattas Creek mine produced 214,853 tons, or 30,721 tons more than in 1904.

The average wage table shows the average earnings of employes to be $463.26 per miner, $579.76 per inside day and monthly man, and $650.98 per outside day and monthly man. Taken as

a whole, the above figures speak favorably as to the condition of mine employes; also that of coal trade generally.

The labor conditions during the entire year were good, no trouble of any consequence having occurred, with the exception of a few strikes of only a few days' duration. The contract between miners and operators covers the period from April 1st, 1904, to April 1st, 1906. This contract was given in our last report, hence we will make no further mention of it.

NEW MINES.

The number of new mines opened and developed during the year was much smaller than in any one of the three years preceding.

In 1902 twenty new mines were opened, and in 1903 thirty-seven, in 1904 forty-two and in 1905 fourteen. This large decrease in the development of new property is probably due to three causes, viz., the unusual activity exhibited in the opening of new mines during the three years prior to 1905, thereby causing an over-production, the reduction in selling prices of coal commencing in 1904 and continuing through 1905, and the organization of large consolidations of the coal interests affected in the State, of which we will make mention later.

The fourteen new mines opened in 1905 are distributed in different counties as follows: Clay County 5, 3 block and 2 bituminous, all of which are hand or pick mines; Knox County 2, both bituminous machine mines; Sullivan County 4, 1 pick and 3 machine, all of which are bituminous mines; Vigo County 2, 1 block and 1 bituminous, both pick mines; Warrick County 1 bituminous, machine mine.

Each of the above mines, especially in the bituminous field, has been opened with a view to having a large output, being equipped throughout with the latest up-to-date machinery, and should add materially to the producing capacity of the State. In the annexed table will be found the names of the different companies owning these mines, the names of the mines, the geological number and thickness of the coal seam mined, the depth and size of shaft, railroad on which the mines are located, location and distance from nearest town or city, and the date on which the first shipment of coal was made.

TABLE OF NEW MINES.

BLOCK COAL MINES.

CLAY COUNTY.

COMPANY.	MINE.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick.	Date of First Shipment of Coal.	Location.	Railroad.
Monarch Block Coal and Mining Co.	Monarch	IV	4′ 6″	70	7 x 16	Pick	9-29-05	3 miles east of Clay City	Evansville & Ind'pls.
Vandalia Coal Co.	Asherville No. 1	III	3′	105	8 x 16	Pick	2- 1-05	¼ mile west of Asherville	South B'ch Vandalia.
Progressive Coal and Mining Co	Progressive	III	3′ 9″	105	8 x 18	Pick	7-25-05	½ mile south of Brazil	Main line Vandalia.

VIGO COUNTY.

COMPANY.	MINE.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick.	Date of First Shipment of Coal.	Location.	Railroad.
Domestic Block Coal Co.	Domestic Block	IV	4′	110	8 x 15	Pick	6- 1-05	4 miles west of Brazil	Chicago & East. Ill.

TABLE OF NEW MINES—Continued.

BITUMINOUS MINES.

CLAY COUNTY.

COMPANY.	MINE.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick.	Date of First Shipment of Coal.	Location.	Railroad.
C. Ehrlich Coal Co..........	Klondike...........	VI	7′	25	8 x 20	Pick......	8-20-05	3 miles west of Brazil........	Main line Vandalia.
Mestor Coal Co	Chicago No. 7......	VI	7′	Slope	....	Pick......	8-19-05	1½ miles S. E. of Coal Bluff.	Chicago & East. Ill.

KNOX COUNTY.

COMPANY.	MINE.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick.	Date of First Shipment of Coal.	Location.	Railroad.
Lynn Coal Co.	Lynn...............	V	6′	190	7 x 13	Machine..	6-15-05	Towns limits of Bicknell....	I. & V. (Vandalia).
Freeman Coal Co...........	Freeman...........	V	7′	234	9 x 18	Machine..	11- 0-05	1 mile S. W. of Bicknell.....	I. & V. (Vandalia).

SULLIVAN COUNTY.

COMPANY.	MINE.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick.	Date of First Shipment of Coal.	Location.	Railroad.
United Fourth Vein Coal Co	Black Hawk	III	6′ 4″	240	9 x 15	Machine..	12- 0-04	¾ mile S. W. of Coalmont...	Southern Indiana.
Carlisle Coal and Clay Co..	Viola...............	VI	4′ 6″	245	10 x 20	Pick.......	Noshipm't	¼ mile west of Carlisle......	Evansville & T. H.
Clover Leaf Coal Co.........	Clover Leaf........	IV	5′ 8″	306	8 x 19	Machine..	3- 0-05	¼ mile west of Cass..........	Illinois Central.
Shirley Hill Coal Co.........	Shirley Hill No. 2..	IV	4′ 7″	307	9 x 18	Machine..	12- 0-05	3½ miles S. W. of Dugger....	I. & V. (Vandalia).

VIGO COUNTY.									
Lower Vein Coal Co........	Lower Vein........	V	4' 6"	201	8 x 16	Pick......	7- 3-05	2 miles N. W. of W. Terre Haute....................	Big Four.
WARRICK COUNTY.									
Elberfield Mining Co.......	Elberfield..........	V	4' 4"	175	7 x 15	Pick......	8- 1-05	½ mile South of Elberfield .	Evansville & Ind'pls.

IMPROVEMENTS.

Large sums of money were spent on improvements of various kinds at the mines in the State during the past year. This expenditure is represented in new tipples, the sinking of second outlets, installation of new machinery and other general improvements. The monthly reports of Coal Companies made to this office during that time show a total of $149,838.12 to have been expended for this purpose, and the following data, while not representing the total amount expended, will show some of the most important improvements made:

The Vivian Coal Company of Clay County has installed an automatic steam lift for handling empty cars at the bottom of their No. 2 mine, which will quite materially reduce the cost of caging the coal as well as increasing the capacity of the mine.

The Clinton Coal Company has installed shaker screens, built additional side tracks and made other general improvements at their No. 1 mine, amounting to about $8,000.

The Caladonia Coal Company of Chandler, Warrick County, sank a new manway during the year and have located their power plant at that point, effecting great improvement in the ventilation of the mine; also adding to its capacity.

The Princeton Coal and Mining Company of Gibson County suspended operations May 1st at their Oswald mine for the purpose of building a new tipple, which was completed August 26th at a cost of $6,500.

The Indiana Southern Coal Company, Sullivan County, has built a new tipple and installed shaker screens at their Citizens' mine, in addition to which they have built side tracks from S. I. R. R., placing the mine on the list of railroad shipping mines.

The Southern Indiana Coal Company, Sullivan County, has sunk and equipped with stairs a second outlet at their Semi-Block Mine.

The Ayrshire Coal Company, Pike County, during the month of September installed a Link Belt Washer at their No. 4 mine. The washer has a capacity of 150 tons per eight hours, and cost $6,000.

The Oak Hill Coal Company of Vermillion County has installed an electric light plant of 125 volts at the bottom of the Oak

Hill mine, the purpose being to light the bottom of the shaft and double partings.

The Diamond Coal Company, Vanderburgh County, has erected a new pit head and tipple, built two new cages and made other extensive improvements at the Diamond mine.

The Indiana Southern Coal Company has installed motor haulage in their Farnsworth mine, Sullivan County; also made other improvements incident to a large output.

The Jackson Hill Coal Company, Sullivan County, has installed a third-rail motor haulage system in the Jackson Hill No. 2 mine.

The Vandalia Coal Company has installed traction motor haulage in the east side of the Island No. 1 mine, Greene County, in addition to which they have expended about $20,000 on improvements of various kinds at many of their other mines.

The Charles F. Keeler Coal Company has added a new generator to their electric light plant at their Atherton mine, Vigo County, also installed two new tubular boilers.

The Crawford Coal Company has completed and equipped with a stairway the second outlet at their No. 4 and No. 8 mines.

The Southern Indiana Coal Company has installed a system of light motor gatherers at the Hoosier No. 1 mine, which not only will reduce the cost of handling the coal, but will add greatly to the producing capacity of the mine.

CHANGES IN OWNERSHIP AND ORGANIZATION OF NEW COAL COMPANIES.

Coal trade during part of 1904 and all of 1905 was generally in a depressed condition. Notwithstanding this fact capital has been more eagerly seeking investment in mining property within the past twelve months than ever before in the history of the State. During that period 81 of the largest producing mines in the State changed hands, these transfers representing an aggregate of approximately thirteen million eight hundred thousand ($13,800,000) dollars, or more than half the production and value of operating plants in the State. There were also seven new coal companies formed during that time, three of which are operating block coal and four bituminous mines. The names and location of these new companies are as follows: The Monarch Block Coal Com-

pany and Progressive Coal Company, both operating block coal mines, are located in Clay County, and the Domestic Block Coal Company in Vigo County. One of the Bituminous Coal Company's mines, the Metzer Coal Company, is located in Clay County. The Clover Leaf Coal Company and Carlisle Coal and Clay Company, both bituminous, are located in Sullivan County. The Lower Vein Coal Company, also bituminous, is located in Vigo County.

Of the 81 mines changing hands, 71 bituminous and 1 block coal mine were bought and their operations assumed by six large coal companies, viz.: The Dering Coal Company, Indiana Southern Coal Company, Southern Indiana Coal Company, Consolidated Indiana Coal Company, United Fourth Vein Coal Company and the Vandalia Coal Company.

The Dering Coal Company was the first of these to organize. On February 1st this company assumed the ownership and operations of the following mines: Bruilettes Creek No. 5, now called Dering No. 5; Riverside, Dering No. 6; Bruilettes Creek No. 3, Dering No. 7; Rhodes, Dering No. 8; Glen Oak, Dering No. 9; Klondike, Dering No. 10; Bruilettes Creek No. 6, Dering No. 12; Mildred, now called Dering No. 13; Wilfred, now the Dering No. 14, and the Willow Grove, which is now known as Dering No. 15.

April the 1st the Indiana Southern Coal Company assumed the ownership and operations of the Gilmour, Bunker Hill, Caladonia, Green Hill, Phoenix No. 1, Phoenix No. 3, Phoenix No. 4, Cummins, Hocking, Citizens' and Forest Park mines. About the same date as above the Southern Indiana Coal Company took over control of seven mines, five of which are located in Greene and two in Sullivan, as follows: Greene County, Hoosier No. 1, Hoosier No. 2, Midland, Tower Hill, Lattis Creek, and in Sullivan County the Semi-Block and Mammoth Vein. June 1st the Consolidated Indiana Coal Company assumed the ownership and operation of 10 mines in Sullivan County, as follows: The Union, now called Consolidated No. 25; Glendoria, now the Consolidated No. 26; Virginia, now Consolidated No. 28; Star City, now Consolidated No. 29; St. Clair, Consolidated No. 30; White Ash, Consolidated No. 31; Hymera No. 2, Consolidated No. 32; Hymera

No. 3, Consolidated No. 33; and Hymera No. 4, now called Consolidated No. 34.

The Vandalia Coal Company was the next to form. September 1st this company took over and assumed the operation of 27 mines, situated along the I. & V., the Logansport Branch, and main line of the Vandalia Railroad, 5 of which are in Clay County, 9 in Greene, 1 in Knox, 3 in Parke, 2 in Sullivan and 7 in Vigo County. The names of the mines prior to the time of their purchase and the numbers under which they are now operated are here given. In Clay County the Asherville No. 1, now called the Vandalia No. 50; Fairview, Vandalia No. 60; Pearl, Vandalia No. 63; Cloverland No. 1, Vandalia No. 64 and the Cloverland No. 2, now called Vandalia No. 65. In Greene County, Island No. 1, now called Vandalia No. 2; Island No. 5, Vandalia No. 4; Island No. 2, Vandalia No. 5; Island No. 3, Vandalia No. 6; South Linton, Vandalia No. 3; Atlas No. 1, Vandalia No. 8; Atlas No. 2, Vandalia No. 9; Island Valley No. 2, Vandalia No. 21, and the White Rose, now called Vandalia No. 20.

In Knox County the Enterprise, now called Vandalia, No. 40. In Parke County, the Minshall No. 1, Vandalia No. 316, Minshall No. 2, Vandalia No. 317, and the Raccoon, now called Vandalia No. 314. In Sullivan County, the Dugger Mine, now called Vandalia No. 30; Island No. 4, Vandalia No. 10. In Vigo County, the Hector, now the Vandalia No. 68; Rose-bud, Vandalia No. 67; Royal, Vandalia No. 66; Broadhurst, Vandalia No. 81; Greenfield No. 1, Vandalia No. 80; Lost Creek, Vandalia No. 69 and Sugar Creek No. 1, now called Vandalia No. 82.

A short time later the United Fourth Vein Coal Company was organized and purchased the following mines: Island Valley No. 4, Black Creek, Island Valley No. 3, Glenburn, Antioch, North Linton and Black Hawk. Sixty-eight of the mines owned and operated by the above coal companies are located in the 5 following counties: Clay, 5; Greene, 22; Sullivan, 26; Vermillion, 5 and Vigo, 10. These 5 counties produced in 1904 7,281,-445 tons of coal, or more than 3/4 of the entire production of bituminous coal of the State; Greene and Sullivan counties alone producing 3,897,938 tons, or nearly 1-3 the total output. Con-

sidering the fact that out of 25 mines in Greene County the 6 companies above mentioned own 22 and of the 34 in Sullivan County they own 26, while in Clay, Knox, Parke, Vermillion and Vigo counties they have purchased none but the largest producing mines, it is evident that considerable more than 1/2 the production of bituminous coal in the State will be controlled by them. In addition to the above the following changes in ownership were made in 1905, viz.: The North West Mine, in Greene County, was bought and operation taken over in December by the Central Coal & Mining Company. The Carbon Mine, in Pike County, was sold during the fall to the Ayrshire Carbon Coal Company. The Winslow Gas Coal Company's property was sold at public sale during the summer, but we have been unable to learn the name of the company who made the purchase. The S. H. Wulfman Coal Company, also in Pike County, reorganized during the fall months and is now known as the Patoka Valley Coal Company. The Lewis Coal & Mining Company, in Clay County, disposed of their mine at Coalmont to the Big Vein Coal Company, of Terre Haute. The Oak Hill and McClellan Sons coal properties in Vermillion County were purchased in October by the Shirkie Bros. The Reliance Coal Company, in Sullivan County, changed hands in November. It was sold to the Peabody Coal Company of Chicago. In Vigo County the old Chicago No. 6, or Monkey Mine, was purchased during October by M. D. West and 3 partners who have secured a new block of coal near the old mine which they will open up.

ABANDONED MINES.

Sixteen mines were abandoned during the year, in addition to which the Caladonia mine, owned by Indiana Southern Coal Company, reduced its working force to less than 10 men. This shows an increase of 2 in number of abandoned mines over the new ones opened.

We exhibit in the following table the names of the mines abandoned, the names of the companies owning them, date of abandonment and the counties in which the mines were located.

TABLE OF ABANDONED MINES.

MINE.	COMPANY.	DATE.	COUNTY.
Gart No. 10	Brazil Block Coal Co	Jan. 1	Clay.
Cornwall	Jackson Coal and Mining Co	Aug. 1	Clay.
Klondike	C. Ehrlich Coal Co	Nov. 14	Clay.
Crawford No. 5	Crawford Coal Co	Feb. 1	Clay.
Montgomery No. 2	Daviess County Coal Co	March 1	Daviess.
Templeton	Coal Bluff Mining Co	May 1	Greene.
Cox No. 3	Brazil Block Coal Co	Aug. 11	Parke.
Lucia	Mecca Coal Co	May 1	Parke.
Raccoon	Vandalia Coal Co	Jan. 1	Parke.
Clay County No. 1	Clay County Coal Co	Jan. 1	Parke
Green Hill	Indiana Southern Coal Co	Jan. 1	Sullivan
Dugger	Vandalia Coal Co	Sept. 10	Sullivan.
Phoenix No. 3	New Pittsburg Coal Co	Jan. —	Sullivan
Buckeye	McClellan Coal Co.	Jan. 1	Vermillion.
Brick Works	Terre Haute Brick and Pipe Co	Jan. 1	Vigo.
Seeleyville	J. Ehrlich Coal Co	Jan. 1	Vigo.
Caladonia	Indiana Southern Coal Co	Sept. 1	Sullivan.

The Caladonia mine has not been entirely abandoned; about six miners are employed loading coal for the Illinois Central Railroad engines.

Added to the above quite a number of large producing mines suspended operations for indefinite periods on account of slack trade, accidents, strikes, etc., all of which combined explains the shortage as shown in the table of production for 1905. We show in the following table the names of mines suspending operations for a period of 30 days or more, the length of time they were idle and the cause of suspension.

SUSPENSIONS.

CLAY COUNTY.

NAME OF MINE.	LENGTH OF TIME IDLE.	CAUSE OF SUSPENSION.
Rebstock	May 1 to July 31	Slack trade.
Superior No. 4	April 1 to July 31	Slack trade.
Fairview	January 1 to December 31	Strike in 1904.
Pearl	August 1 to October 31	During change of ownership.
Crawford No. 8	February 1 to December 31	Slack trade.
Fortner	January 1 to July 31	Slack trade.
Glen No. 1	April 1 to April 30	Cause unknown.
World's Fair No. 2	April 1 to August 31	Slack trade.
Island Valley No. 4	April 1 to August 31	Slack trade, change in ownership.
Superior No. 4	March 1 to July 31	Slack trade.
Gifford No. 2	February 11 to October 31	Slack trade, making repairs.
Harrison No. 3	April 1 to October 31	Making repairs, slack trade.

GREENE COUNTY.

NAME OF MINE.	LENGTH OF TIME IDLE.	CAUSE OF SUSPENSION.
Island Valley No. 3	April 1 to September 30	Flooded, changed ownership.
Glenburn	June 1 to August 31	Slack trade.
Atlas No. 2	April 1 to October 31	Slack trade.
Island No. 3	June to September	Mine flooded and no orders.
Hoosier No. 2	January to September	Slack trade.
Midland	April 11 to May 31	Slack trade.
Letsinger	September, 1904, to October, 1905	Cause unknown.
Island No. 4	May 1 to 31	Strike.

SUSPENSIONS—Continued.

KNOX COUNTY.

Name of Mine.	Length of Time Idle.	Cause of Suspension.
Bicknell	June 1 to July 31	Slack trade.
Lynn	February 1 to April 30	Slack trade.
Enterprise	March 1 to October 1	Slack trade.

PARKE COUNTY.

Superior No. 3	April 1 to June 30	Slack trade.
Minshall No. 1	April 1 to August 31	No orders, change ownership.
Minshall No. 2	April 1 to June 30	Slack trade.

PIKE COUNTY.

Blackburn	June 1 to August 31	Mine flooded.
Winslow Nos. 3 and 5	Idle entire year	In hands receiver, sold.

SULLIVAN COUNTY.

Shirley Hill No. 1	May 1 to June 30	Making repairs.
Bunker Hill	April 1 to July 31	Making repairs.
New Linton	June 1 to December 1	Strike, slack trade.
Shelburn	January to September	Completing equipment.
Reliance	September 1 to October 30	In hands of receiver, sold.
Linton Bituminous	April to October	Slack trade.
Freeman	May 1 to October 1	Making repairs.

GIBSON COUNTY.

Oswald	May 1 to August 26	Rebuilding tipple.

VIGO COUNTY.

Hector	April 1 to September 1	No orders, change ownership.

WARRICK COUNTY.

Chandler	June 1 to August 31	Slack trade.
Star City No. 1	April 1 to October 1	Slack trade.

TABLE

Showing by Counties the Name of Mine, Number of Tons Screened, Slack and Nut and Mine Run Coal, Total Tons of All Grades of Coal Produced, and the Distribution Thereof, the Production of Block and Bituminous Coal, Each Being Shown Separately, as is the Machine and Pick or Hand Mined Coal.

BLOCK COAL MACHINE MINES.

CLAY COUNTY.

NAME OF MINE	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 1	26,361	5,110	....	31,471	110	20	....	130	14,339	17,262	$20,926 51	$13,818 16	$6,917 68	$41,662 35
Brazil Block No. 8	1,873	380	....	2,253	16,556	3,330	....	19,886	2,028	20,111	19,966 69	13,103 76	6,844 82	39,915 27
Total	28,234	5,490	....	33,724	16,666	3,350	....	20,016	16,367	37,373	$40,893 20	$26,921 92	$13,762 50	$81,577 62

PARKE COUNTY.

NAME OF MINE	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 12	255	30	....	285	16,074	3,230	....	19,304	5,252	14,337	$18,092 67	$9,819 30	$5,402 16	$33,314 13
Mary	37,408	3,656	....	41,064	4,213	475	....	4,688	858	44,894	31,879 53	17,262 29	8,268 04	57,409 86
Total	37,663	3,686	....	41,349	20,287	3,705	....	23,992	6,110	59,231	$49,972 20	$27,081 59	$13,670 20	$90,723 99
Total Machine Block Coal	65,897	9,176	....	75,073	36,953	7,055	....	44,008	22,477	96,604	$90,865 40	$54,003 51	$27,432 70	$172,301 61

BITUMINOUS MACHINE MINES.

CLAY COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Gifford No. 1	17,544	9,770	3,240	30,554	13,049	....	....	13,049	13,049	30,554	$26,163 66	$13,337 28	$5,118 82	$44,619 76
Gifford No. 2	4,356	3,545	1,801	9,702	10,254	229	927	11,410	5,217	15,895	14,021 27	8,791 86	2,890 02	25,703 15
Lewis	....	....	68,732	68,732	....	....	865	865	46,014	23,583	31,287 30	4,974 40	5,621 52	41,883 22
Vivian No. 1	4,040	6,932	....	10,972	864	2,048	....	2,912	8,068	5,816	8,595 57	2,639 04	5,686 26	16,920 87
Vivian No. 2	10,073	11,590	33,119	54,782	....	....	....	....	47,491	7,291	27,567 12	8,420 97	6,306 35	42,294 44
Gold Knob	27,598	12,553	7,368	47,519	1,452	379	179	2,010	16,894	32,635	19,438 84	13,191 18	9,705 70	42,335 72
Island Valley No. 4	15,717	7,350	8,126	31,193	....	....	....	....	17,720	13,473	13,847 22	6,309 66	3,178 59	23,335 47
Total	79,328	51,740	122,386	253,454	25,619	2,656	1,971	30,246	154,453	129,247	$140,920 98	$57,664 39	$38,507 26	$237,092 63

GREENE COUNTY.

NAME OF MINE.	Machine Mined: Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Pick Mined: Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Distribution: Indiana.	Other States.	Wages Paid: To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Black Creek	24,369	16,840	11,293	57,502	26,673	15,949	10,245	52,867	66,524	43,845	$55,948 21	$22,798 21	$7,884 54	$86,630 87
Vandalia No. 2	....	....	35,173	35,173	....	....	71,133	71,133	84,220	22,086	52,300 69	23,173 74	7,437 53	82,911 96
Vandalia No. 5	36,546	15,266	17,209	69,021	36,876	15,724	17,937	70,537	91,316	48,242	73,618 51	27,909 69	12,914 79	114,442 99
Vandalia No. 21	10,135	5,225	18,761	34,121	....	....	....	....	19,357	14,764	13,867 01	7,422 54	6,144 95	27,434 50
Vandalia No. 8	38,237	23,912	76,675	138,824	4,140	1,909	7,259	13,308	139,884	12,248	74,661 98	31,295 75	12,111 22	118,068 95
Vandalia No. 9	....	....	9,691	9,691	....	....	13,169	13,169	22,860	....	12,721 69	4,958 07	4,021 26	21,701 02
Gilmour	....	....	103,229	103,229	....	....	....	....	49,529	53,700	63,015 00	19,555 00	7,316 00	89,886 00
Hoosier No. 1	22,566	16,224	23,154	61,944	....	....	....	....	12,694	49,250	28,003 13	17,959 11	8,346 41	54,308 65
Midland	25,649	13,328	16,624	55,601	42	13	11	66	15,833	39,834	26,454 45	10,440 04	8,341 25	45,235 74
Summitt No. 2	43,219	21,802	72,712	137,733	....	....	....	....	80,681	57,052	59,667 28	27,931 43	15,576 33	103,175 04
Glenburn	7,355	3,412	4,854	15,621	14,635	7,968	8,490	31,093	39,060	7,654	29,538 98	15,906 97	5,545 42	50,991 37
Antioch	329	198	293	820	13,403	11,221	43,927	68,551	62,395	6,976	44,300 96	17,245 80	7,617 20	69,163 96
Lattis Creek	90,205	84,813	35,680	210,698	2,435	812	878	4,155	117,684	97,169	112,951 70	44,692 92	16,609 73	174,254 35

Twin	62,164	28,284	61,167	151,615	....	....	....	....	127,614	24,001	78,696 05	19,844 07	12,484 40	111,026 52
North Western	24,549	12,236	12,788	49,573	403	163	38	604	39,575	10,602	23,111 62	16,230 15	8,143 29	47,485 06
Tower Hill	18,042	9,724	2,725	30,491	8,361	4,594	10,813	23,758	12,791	41,458	28,995 87	9,319 22	6,312 37	44,627 46
Green Valley	54,109	34,656	21,442	110,206	....	....	....	....	67,968	42,244	49,158 39	17,216 85	9,396 29	75,771 53
Total	462,474	185,920	523,470	1,271 864	106,958	58,383	183,900	349,241	1,049,980	571,125	$827,013 52	$333,899 47	$156,202 98	$1,317,115 97

KNOX COUNTY.

Lynn	....	....	12,764	12,764	....	....	5,796	5,796	16,382	2,178	$7,683 84	$4,121 45	$3,704 71	$15,510 00
Enterprise	....	....	1,512	1,512	1,449	1,242	7,915	10,606	12,118	....	5,819 19	2,135 55	2,053 98	10,008 72
Pine Knot	11,809	5,909	3,900	21,618	150	350	150	650	16,875	5,393	11,612 65	8,513 50	11,406 30	31,532 45
Total	11,809	5,909	18,176	35,894	1,599	1,592	13,861	17,052	45,375	7,571	$25,115 68	$14,770 50	$17,164 99	$57,051 17

PARKE COUNTY.

Mecca No. 3	25,602	8,363	6,024	39,989	50,519	22,519	14,270	87,308	77,489	49,808	$69,084 09	$19,839 38	$10,805 86	$99,729 83
Lyford No. 1	3,327	1,981	4,482	9,790	6,213	3,814	27,995	38,022	....	47,812	27,542 15	14,791 29	7,404 23	49,737 67
Parke No. 11	....	....	92,456	92,456	....	....	22,358	22,358	84,685	30,129	55,349 55	16,767 89	6,664 10	78,781 54
Total	28,929	10,344	120,962	142,235	56,732	26,333	64,623	147,688	162,174	127,749	$151,975 79	$51,398 56	$24,874 19	$228,248 54

PIKE COUNTY.

Hartwell	....	....	....	....	7,105	4,621	66,555	78,281	61,011	17,270	$46,158 21	$13,546 37	$7,633 41	$67,337 99
Total	....	....	....	....	7,105	4,621	66,555	78,281	61,011	17,270	$46,158 21	$13,546 37	$7,633 41	$67,337 99

BITUMINOUS MACHINE MINES—Continued.

SULLIVAN COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Bunker Hill	9,262	5,030	19,434	33,726	2,770	1,385	....	4,155	10,200	27,681	$18,821 84	$8,135 26	$4,070 55	$31,027 65
Caladonia	13,542	5,157	2,492	21,191	....	....	225	225	2,314	19,102	7,270 98	6,208 82	4,964 13	18,443 93
Consolidated No. 32	30,127	33,119	37,933	101,179	861	1,346	1,506	3,713	19,754	85,138	41,122 02	15,230 74	11,046 85	67,399 61
Consolidated No. 33	50,696	42,526	56,222	149,444	3,181	5,443	504	9,128	19,656	138,916	64,517 51	21,581 40	12,086 54	98,185 45
Consolidated No. 34	2,141	8,403	49,427	59,971	....	....	....	....	27,306	32,665	28,944 24	12,897 90	13,562 76	55,404 90
Consolidated No. 29	58,705	37,271	256	96,232	118	232	....	350	15,586	80,996	49,343 65	29,260 99	13,655 64	92,260 28
Consolidated No. 31	1,537	589	624	2,750	3,851	2,182	20,693	26,726	7,188	22,288	17,408 75	4,430 30	3,213 62	25,052 67
Consolidated No. 26	34,626	17,596	....	52,222	90	187	....	277	8,766	43,733	25,360 99	12,490 08	5,759 96	43,611 03
Consolidated No. 28	33,586	25,505	42,434	101,525	29	60	....	89	41,143	60,471	28,033 46	12,434 56	7,507 38	47,975 40
Consolidated No. 30	24,726	14,464	613	39,803	....	....	....	....	13,541	26,262	19,270 85	11,367 43	7,879 31	38,517 59
Consolidated No. 25	9,966	11,640	85	21,691	72	141	....	213	4,146	17,758	12,117 60	6,878 86	3,930 06	22,926 52
Vandalia No. 30	13,872	5,397	5,941	25,210	104	21	83	208	17,262	8,156	12,514 50	8,408 65	6,607 37	27,530 52
Vandalia No. 10	....	....	....	....	41,217	17,120	35,186	93,523	93,523	....	56,768 95	12,169 35	6,796 62	75,734 92
New Linton	4,024	2,000	6,506	12,530	....	....	....	....	12,530	....	5,557 60	4,375 17	2,755 50	12,688 27
Jackson Hill No. 2	86,745	29,175	32,235	148,155	....	....	....	....	14,371	133,784	70,459 22	27,919 35	10,380 56	108,759 13
Jackson Hill No. 4	15,850	8,325	....	24,175	16,806	18,555	4,483	39,844	6,791	57,228	36,277 88	8,270 06	7,671 20	52,219 14
Phoenix No. 4	....	....	38,349	38,349	....	....	....	....	16,884	21,465	20,315 83	8,323 00	5,629 00	34,267 83
Shelburn	3,220	....	4,180	7,400	....	....	....	....	2,568	4,832	2,795 00	4,300 00	6,371 90	13,466 90
Sun Flower	102,535	30,070	719	133,324	....	....	....	....	2,697	130,627	72,068 06	12,497 61	11,581 63	96,147 30
Hamilton	Idle, no	report.												
Dering No. 14	86,390	67,873	7,625	161,888	....	....	....	....	6,584	155,304	80,279 76	27,297 07	21,296 29	128,873 12
Dering No. 12	....	....	....	....	34,865	14,879	15,850	65,594	12,346	53,248	45,717 60	15,349 26	10,005 77	71,072 63
Dering No. 13	17,343	8,592	59,446	85,381	8,709	4,466	7,782	10,957	19,751	86,587	50,854 99	17,272 62	11,461 70	79,589 31
Semi-Block	15,309	9,164	11,724	36,197	193	113	223	529	7,621	29,105	19,879 75	15,183 31	8,377 83	43,440 89
Mammoth Vein	15,028	9,943	1,794	26,765	....	....	....	....	....	26,765	12,805 83	7,428 36	6,165 50	26,399 69
Shirley Hill No. 1	5,869	1,823	52,196	59,888	3,277	1,555	23,670	28,502	88,390	....	33,768 55	11,040 80	5,828 60	50,637 95
Cummins	....	....	13,264	13,264	....	....	17,180	17,180	12,744	17,700	19,055 00	7,772 00	4,038 00	30,865 00

Hocking	71,179	44,537	33,885	149,601	1,838	862	128	2,828	47,970	104,459	77,577 71	25,353 90	16,145 10	119,076 71
Citizens	2,914	986	5,988	9,888	....	....	....	....	9,888	....	4,928 13	1,772 40	2,211 89	9,012 42
Kettle Creek	19,102	10,410	3,954	33,466	200	50	10	260	21,101	12,625	18,238 21	11,201 39	6,574 81	36,014 41
Reliance	8,819	4,896	3,338	17,053	....	....	2,250	2,250	87	19,216	10,006 46	10,931 83	9,702 92	30,641 21
Little Giant	17,397	7,516	100,448	125,361	13,251	2,226	14,733	30,210	155,571	....	64,020 39	28,568 47	14,218 19	106,807 05
Black Hawk	2,793	1,475	8,597	12,865	2,365	1,413	856	4,634	9,427	8,072	8,440 66	9,587 85	5,519 54	23,548 05
Clover Leaf	3,760	991	1,768	6,519	72	18	31	121	3,161	3,479	4,022 79	1,983 56	3,967 36	9,973 71
Total	761,063	444,473	601,477	1,807,013	133,869	72,254	145,393	351,516	730,867	1,427,662	$1,038,564 76	$418,022 35	$270,984 08	$1,727,571 19

VIGO COUNTY.

Atherton	29,890	15,880	13,716	59,486	5,370	2,971	2,289	10,630	9,248	60,868	$34,057 67	$15,631 42	$8,377 64	$58,066 73
Parke No. 10	19,925	19,023	65,195	104,143	....	....	5,222	5,222	82,641	26,724	55,028 14	20,852 00	12,717 29	88,597 43
Ray No. 2	7,898	4,376	9,505	21,779	26,000	12,011	27,808	65,819	64,983	22,615	52,344 25	8,762 01	7,433 95	68,530 21
Forrest Park	....	....	35,652	35,652	....	....	....	....	17,226	18,426	20,421 00	5,925 00	4,701 00	31,047 00
Glen Oak	798	....	....	798	20,795	10,856	70,600	102,251	798	102,251	52,353 37	29,123 05	9,224 54	90,700 96
Klondike	798	....	....	798	169	181	103,343	103,693	838	103 653	54,019 25	23,350 02	8,593 08	85,962 35
Vandalia No. 82	11,671	3,244	5,751	20,666	31,922	12,983	7,125	52,030	52,851	19,845	46,576 66	14,007 06	7,396 18	67,978 90
Total	70,980	42,523	129,819	243,322	84,256	39,002	216,387	339,645	228,585	354,382	$314,800 34	$117,640 56	$58,442 68	$490,883 58

WARRICK COUNTY.

Big Four	7,294	4,856	45,651	57,801	230	149	6,085	6,464	51,330	12,935	$27,305 09	$7,184 74	$4,903 12	$39,392 95
Big Vein No. 3	....	....	95,606	95,606	....	....	....	....	95,606	....	40,934 16	8,359 53	5,276 05	54,569 74
Chandler	6,717	3,028	16,074	25,819	....	....	....	....	25,819	....	12,097 55	2,381 55	1,816 55	16,295 65
De Forrest	4,070	1,970	240	6,280	....	....	....	....	6,280	....	2,792 87	613 78	423 52	3,830 17
Electric	....	....	122,409	122,409	....	....	....	....	48,752	73,657	49,120 05	14,585 78	6,162 68	69,868 51
Total	18,081	9,854	279,980	307,915	230	149	6,085	6,464	227,787	86,592	$132,249 72	$33,125 38	$18,581 92	$183,957 02
Total Bituminous Machine Mines	1,432,664	850,763	1,778,270	4,061,697	416,368	204,990	698,775	1,320,133	2,660,232	2,721,598	$2,676,799 00	$1,040,067 58	$592,391 51	$4,309,258 09

BLOCK COAL—HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Production. Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Distribution. Indiana.	Other States.	Wages. To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Brazil Block No. 4	33,947	6,795	....	40,742	5,227	35,515	$37,815 49	$11,573 08	$7,917 51	$57,306 08
Gart No. 7	42,892	8,585	....	51,477	31,606	19,871	47,609 07	10,045 91	6,223 44	63,878 42
Continental No. 1	1,126	212	5,133	6,471	6,471	....	5,110 69	1,996 01	1,448 24	8,554 94
Rabstock	13,208	2,845	....	16,053	2,112	13,941	12,565 14	5,010 81	2,771 92	20,347 87
Superior No. 4	13,653	3,310	....	16,963	15,834	1,129	18,197 58	7,674 47	3,451 76	29,323 81
Superior No. 7	20,465	5,025	219	25,709	25,427	282	23 559 68	10,790 56	4,970 51	39,320 75
Cornwall	10,189	673	....	10,862	....	10,862	10,713 28	2,418 95	1,181 82	14,314 05
Crawford No. 4	15,576	3,804	20	19,400	14,262	5,138	17,246 67	6,962 19	4,003 60	28,212 46
Crawford No. 5	1,632	350	....	1,982	482	1,500	1,631 64	499 27	337 20	2,468 11
Crawford No. 8	782	150	....	932	532	400	773 66	319 92	260 17	1,353 75
Crawford No. 9	14,571	3,280	....	17,851	6,457	11,394	14,503 00	6,769 11	4,113 68	25,385 79
Monarch	....	....	5,355	5,355	5,355	....	9,450 00	2,976 88	1,020 04	13,446 92
Indiana Block	9,407	2,160	1,537	13,104	5,105	7,999	13,780 58	7,598 55	3,824 16	25,203 29
World's Fair No. 2	5,931	1,748	....	7,679	7,679	....	8,312 30	2,902 19	2,303 37	13,517 86
Crawford No. 6	50,415	11,520	381	62,316	22,479	39,837	52,100 48	11,029 51	5,564 79	68,694 78
Vandalia No. 50	9,210	3,427	56	12,693	10,659	2,034	10,869 07	3,992 93	2,621 40	17,483 40
Eureka No. 5	10,469	1,845	32	12,346	7,227	5,119	12,180 20	2,576 90	3,542 45	18,299 55
Totals	253,473	55,729	12,733	321,935	166,914	155,021	$296,418 53	$95,137 24	$55,556 06	$447,111 83

PARKE COUNTY.

Brazil Block No. 9	30,113	6,030	....	36,143	11,562	24,581	$32,893 63	$11,606 81	$6,419 08	$50,919 52
Superior No. 1	39,494	10,070	122	49,686	49,686	....	41,803 63	17,079 50	8,148 48	67,031 61
Superior No. 2	44,760	11,585	671	57,016	57,016	....	48,776 90	19,947 76	9,913 75	78,638 41
Superior No. 3	19,013	4,980	....	23,993	23,993	....	20,336 58	5,614 69	2,597 68	28,548 95
Pan American	36,030	6,585	145	42,760	14,730	28,030	39,767 45	13,350 70	6,125 80	59,143 95
Totals	169,410	39,250	938	209,598	156,987	52,611	$183,578 19	$67,499 46	$33,204 79	$284,282 44

VIGO COUNTY.

Domestic block	4,871	3,250	....	8,121	4,957	3,164	$9,010 35	$2,678 38	$2,116 61	$13,805 34
Totals	4,871	3,250	....	8,121	4,957	3,164	$9,010 35	$2,678 38	$2,116 61	$13,805 34
Total hand mined block	427,754	98,229	13,671	539,654	328,858	210,796	$489,007 07	$165,315 08	$90,877 46	$745,199 61

BITUMINOUS HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Vandalia No. 64	39,208	17,141	6,665	63,014	60,980	2,034	$36,376 34	$9,783 64	$5,171 34	$51,331 32
Vandalia No. 65	44,962	22,061	10,944	77,967	74,470	3,497	49,876 05	8,484 12	4,086 14	62,446 31
Vandalia No. 60. Idle, no report.										
Vandalia No. 63	10,336	6,563	1,256	18,155	17,031	1,124	9,390 44	1,947 71	1,447 07	12,785 22
Fortner	1,549	494	....	2,043	2,043	....	1,915 61	755 90	120 44	2,791 95
Klondike	2,580	1,338	....	3,918	3,918	....	2,209 28	515 34	514 72	3,239 34
Glenn No. 1	14,211	2,866	....	17,077	....	17,077	14,047 40	4,320 05	2,159 90	20,527 35
Glenn No. 2	6,642	1,680	....	8,322	....	8,322	6,743 55	3,283 15	1,641 55	11,668 25
Total	119,488	52,143	18,865	190,496	158,442	32,054	$120,558 67	$29,089 91	$15,141 16	$164,789 74

DAVIESS COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Stucky	....	....	2,356	2,355	2,355	....	$1,365 15	$234 87	$198 94	$1,798 96
Montgomery No. 3	36,312	1,476	2,441	40,229	31,591	8,638	30,610 56	13,539 25	7,640 35	51,790 16
Mutual	8,600	950	14,700	24,250	15,600	8,650	22,163 00	6,450 00	4,700 00	33,313 00
Mandabach	....	....	9,819	9,819	9,819	....	6,747 53	672 81	727 48	8,147 82
Total	44,912	2,426	29,315	76,653	59,365	17,288	$60,886 24	$20,896 93	$13,266 77	$95,049 94

FOUNTAIN COUNTY.

Rush	21,213	8,366	11,075	40,654	40,224	430	$26,480 99	$6,106 84	$4,762 62	$37,350 45
Silverwood	832	620	28,984	30,436	29,863	573	20,750 57	6,587 81	3,721 71	31,060 09
Total	22,045	8,986	40,059	71,090	70,087	1,003	$47,231 56	$12,694 65	$8,484 33	$68,410 54

GIBSON COUNTY.

Oswald	18,209	16,185	8,160	42,554	38,941	3,613	$24,557 78	$7,228 83	$5,931 46	$37,718 07
Massey	7,143	5,455	26,835	39,433	39,433	....	23,352 28	7,630 20	5,689 50	36,671 98
Fort Branch	....	....	18,959	18,959	18,959	....	12,720 17	3,378 92	2,230 10	18,329 19
Total	25,352	21,640	53,954	100,946	97,333	3,613	$60,630 23	$18,237 95	$13,851 06	$92,719 24

GREENE COUNTY.

Vandalia No. 6	....	....	31,435	31,435	31,435	....	$17,173 82	$6,970 46	$3,353 71	$27,497 99
Vandalia No. 4	10,900	4,891	37,337	53,128	53,128	....	31,967 73	7,210 56	3,563 54	42,741 83
Vandalia No. 3	36,086	20,218	51,205	107,509	81,576	25,933	61,673 05	19,118 99	7,230 02	88,[illegible]22 06
Hoosier No. 2	....	....	4,238	4,238	4,238	....	5,660 51	2,028 42	1,214 41	8,903 34
Island Valley No. 3	9,604	4,886	10,603	25,093	16,172	8,921	15,530 85	5,442 15	3,235 96	24,208 96
Templeton	1,273	430	15,556	17,259	17,259	....	10,067 50	3,369 00	1,674 25	15,110 75
Victoria	93,380	73,[illegible]97	113,991	280,768	262,988	17,780	158,863 87	32,775 92	13,1[illegible]6 18	204,825 97
North Linton	31,246	16,246	8,545	56,037	39,683	16,354	37,302 29	11,596 02	5,911 33	54,809 64
Pennsylvania	8,867	4,448	5,110	18,425	9,121	9,304	8,968 31	2,475 83	3,008 43	14,452 57
Total	191,356	124,516	278,020	593,892	515,600	78,292	$347,207 93	$90,987 35	$42,377 83	$180,573 11

KNOX COUNTY.

Bicknell	14,752	12,499	13,427	40,678	28,438	12,240	$22,728 97	$6,156 39	$4,570 12	$33,455 48
Knox	29,981	30,210	17,443	77,634	35,000	42,634	41,833 84	11,036 86	4,691 44	57,562 14
Wheatland	1,320	544	50,842	52,706	52,706	....	31,556 26	6,320 04	3,735 61	41,611 91
Total	46,053	43,253	81,712	171,018	116,144	54,874	$96,119 07	$23,513 29	$12,997 17	$132,629 53

BITUMINOUS HAND OR PICK MINES—Continued.

PARKE COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Cox No. 3	....	....	44,897	44,897	26,214	18,683	$25,253 74	9,106 52	$5,001 28	$39,361 54
Harrison	....	....	12,822	12,822	12,822	....	8,372 78	1,453 37	970 00	10,796 15
Lucia	4,514	1,738	5,920	12,172	9,500	2,672	7,317 06	4,147 47	1,618 63	13,083 19
Vandalia No. 316	41,390	13,661	360	55,411	36,221	19,190	38,324 09	14,113 48	7,005 64	59,443 21
Vandalia No. 317	38,397	11,421	31	49,849	25,658	24,191	36,217 71	8,305 12	3,974 40	48,497 23
Total	84,301	26,820	64,030	175,151	110,415	64,736	$115,485 38	$37,125 96	$18,569 95	$171,181 26

PERRY COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Troy	....	....	7,895	7,895	7,895	....	$5,121 42	$1,641 15	$1,142 50	$7,905 07
Total	....	....	7,895	7,895	7,895	....	$5,121 42	$1,641 15	$1,142 50	$7,905 07

PIKE COUNTY.

Aberdeen	Idle no	report.	....	....	....	....	....	....	....	....
Carbon	Idle no	report.	....	....	....	....	....	....	....	....
Ayrshire No. 3	34,622	21,611	4,179	60,412	36,083	24,329	$31,498 73	$11,715 63	$5,483 33	$48,697 69
Ayrshire No. 4	50,862	35,643	45,432	131,937	60,205	71,732	75,746 24	20,540 56	9,515 81	105,802 61
Ayrshire No. 5	....	....	3,587	3,587	3,587	....	2,436 04	929 79	630 99	3,996 82
Rogers	....	....	6,986	6,986	6,986	....	3,852 76	885 43	119 57	4,857 76
Blackburn	....	....	6,584	6,584	6,584	....	3,460 31	1,300 00	1,064 14	5,824 45
Littles	39,953	56,365	4,742	101,060	63,847	37,213	55,639 11	15,341 66	6,413 52	77,394 29
Winslow No. 2	Idle no	report.	....	....	....	....	....	....	....	....
Winslow No. 5	Idle no	report.	....	....	....	....	....	....	....	....
Total	125,437	113,619	71,510	310,566	177,292	133,274	$172,633 19	$50,713 07	$23,227 36	$246,573 62

SULLIVAN COUNTY.

Phoenix No. 1	....	....	2,210	2,210	1,000	1,210	$1,300 00	$620 00	$240 00	$2,160 00
Freeman	6,618	3,306	2,404	12,358	3,674	8,684	7,863 01	2,178 79	1,364 16	11,405 96
Vandalia No. 10	41,217	17,120	35,186	93,523	93,523	....	56,768 95	12,169 35	6,796 62	75,734 92
Dering No. 12	34,865	14,879	15,850	65,594	12,346	53,248	45,717 60	15,349 26	10,005 77	71,072 63
Superior	24,125	14,699	16,641	55,465	33,157	22,308	30,240 72	14,302 64	4,166 35	48,709 71
Total	106,855	50,004	72,291	229,150	143,700	85,450	$141,890 28	$44,620 04	$22,572 90	$209,083 22

VANDERBURGH COUNTY.

Unity	28,722	25,837	65,122	119,681	119,681	....	$72,221 85	$17,430 70	$9,710 05	$99,362 60
Diamond	17,194	10,634	7,387	35,215	35,215	....	21,717 94	5,709 06	4,562 72	31,989 72
First Avenue	9,253	8,974	9,242	27,469	25,945	1,524	17,332 45	4,412 35	3,883 15	25,627 95
Ingleside	1,988	....	40,036	42,024	42,024	....	25,613 43	6,680 10	5,956 72	38,250 25
Sunnyside	30,784	28,075	269	59,128	50,144	8,984	26,842 23	11,355 07	11,557 63	49,754 93
Union	9,698	5,414	9,152	24,264	24,264	....	18,646 50	3,379 85	4,567 30	26,593 65
Total	97,639	78,934	131,208	307,781	297,273	10,508	$182,374 40	$48,967 13	$40,237 57	$271,579 10

BITUMINOUS HAND OR PICK MINES—Continued.

VERMILLION COUNTY.

NAME OF MINE.	Production. Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Distribution. Indiana.	Other States.	Wages. To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Dering No. 5	58,444	32,025	120,791	211,260	19,679	191,581	$111,017 53	$41,891 16	$9,951 58	$162,860 27
Dering No. 6	15,232	6,055	173,366	194,653	14,778	179,875	100,664 08	30,348 86	7,031 14	138,044 08
Dering No. 7	....	....	145,012	145,012	1,865	143,147	76,687 73	26,442 37	6,601 52	109,731 62
Dering No. 8	61,182	42,183	81,106	187,471	25,894	161,577	105,046 36	38,198 21	8,981 76	152,226 33
Dering No. 15	576	610	105,900	107,086	....	107,086	54,548 36	20,737 40	5,657 40	80,943 16
Eureka	....	....	10,655	10,655	10,655	....	6,201 18	2,457 42	2,265 36	10,923 96
Buckeye No. 2	....	....	....	....	....	....	....	....	....	....
Crown Hill No. 1	23,366	7,763	50,945	82,074	21,249	60,825	61,821 15	12,493 17	4,323 80	78,638 12
Crown Hill No. 2	30,912	10,636	75,512	117,060	26,479	90,581	91,114 40	17,488 80	4,846 58	113,449 78
Oak Hill	6,397	4,310	58,165	68,872	....	68,872	39,043 32	10,814 66	1,844 22	51,702 20
Prince	....	....	165,884	165,884	....	165,884	97,667 41	27,820 88	7,799 71	133,288 00
Maple Valley	6,636	4,945	83,074	91,655	17,226	77,429	59,040 37	11,443 75	6,510 65	76,994 77
Total	205,745	108,527	1,070,410	1,384,682	137,825	1,246,857	$802,851 89	$240,136 68	$65,813 72	$1,108,802 29

VIGO COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Chicago No. 6	No repo	rt	....	....	....	....	....	....	....	....
Diamond	49,080	22,964	41,385	113,429	113,429	....	$66,174 30	$22,858 70	$9,314 10	$98,347 10
Peerless	6,108	1,110	12,257	19,475	2,229	17,246	12,566 35	6,865 10	3,432 60	22,844 05
Lawton	88,671	52,566	45,697	186,934	186,934	....	113,769 10	25,766 30	10,391 05	149,926 45
Grant No. 2	393	26,525	122,162	149,080	124,147	24,933	86,359 20	30,496 42	12,475 04	129,330 66
Miami No. 1	84,741	78,534	....	163,275	....	163,275	98,002 76	28,214 53	9,028 17	135,245 46
Miami No. 2	35,770	37,695	14,267	87,732	....	87,732	41,192 15	11,590 85	3,979 92	56,762 92
Miami No. 3	57,521	27,699	15,266	100,486	....	100,486	60,560 83	13,978 13	4,230 69	78,769 65
Redbird	18,177	15,334	12,654	46,165	46,165	....	21,834 76	11,507 61	3,008 49	36,350 86

Vandalia No. 67	29,978	16,388	76,285	122,651	116,214	6,437	73,236 26	21,707 86	5,923 37	100,867 49
Vandalia No. 66	27,743	17,211	6,733	51,687	50,569	1,118	29,453 42	11,014 29	3,719 26	44,186 97
Vandalia No. 81	25,556	24,927	17,867	68,350	49,422	18,928	24,462 58	6,587 20	6,487 73	37,537 51
Vandalia No. 80	6,132	4,070	14,431	24,633	24,493	140	15,376 42	4,688 15	1,642 49	21,707 06
Vandalia No. 69	34,597	58,104	4,234	96,935	93,182	3,753	53,059 90	12,196 82	6,348 25	71,606 97
Deep Vein	31,488	18,036	21,362	70,886	51,634	19,252	49,375 42	8,623 80	6,105 22	64,104 44
Vandalia No. 68	5,097	3,020	23	8,140	6,570	1,570	4,830 48	2,231 58	1,697 62	8,809 68
Totals	501,052	404,183	404,623	1,309,858	864,988	444,870	$750,253 93	$218,379 34	$67,784 00	$1,056,417 27

WARRICK COUNTY.

Air Line	400	200		600	400	200	$325 00	$115 00	$65 00	$505 00
Star No. 1			17,709	17,709	17,709		10,390 77	2,765 03	1,577 08	14,732 88
Burk			7,920	7,920		7,920	4,118 40	1,204 73	860 37	6,183 50
Caladonia	Reduced	to less th	an ten m	en						
Totals	400	200	25,629	26,229	18,109	8,120	$14,834 17	$4,084 76	$2,502 45	$21,421 38
Total bituminous pick-mined coal	1,570,635	1,035,251	2,349,521	4,955,407	2,774,468	2,180,939	$2,918,078 36	$841,088 21	$367,968 77	$4,127,135 34

RECAPITULATION.

Showing Total Production and Wages of Indiana Mines for 1905.

TOTAL PRODUCTION OF BLOCK COAL.

	Machine Mined.				Pick Mined.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of All Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Total machine mined block coal	65,897	9,176	....	75,073	36,953	7,055	....	44,008	22,477	96,604	$90,865 40	$54,003 51	$27,432 70	$172,301 61
Total pick mined block coal	....	....	....	....	427,754	98,229	13,671	539,654	328,858	210,796	489,007 07	165,315 08	90,877 46	745,199 61
Total block coal..	65,897	9,176	....	75,073	464,707	105,284	13,671	583,662	351,335	307,400	$579,872 47	$219,318 59	$118,310 16	$917,501 22

TOTAL PRODUCTION OF BITUMINOUS COAL.

Total bituminous machine mined coal	1,432,664	850,763	1,778,270	4,061,697	416,368	204,990	698,775	1,320,133	2,660,232	2,721,598	$2,676,799 00	$1,040,067 58	$592,391 51	$4,309,258 09
Total bituminous pick mined coal	....	....	....	....	1,570,635	1,035,251	2,349,521	4,955,407	2,774,468	2,180,939	2,918,078 36	841,088 21	367,968 77	4,127,135 34
Total bituminous coal	1,432,664	850,763	1,778,270	4,061,697	1,987,003	1,240,241	3,048,296	6,275,540	5,434,700	4,902,537	$5,594,877 36	$1,881,155 79	$960,360 28	$8,436,393 43
Total machine mined coal	1,498,561	859,939	1,778,270	4,136,770	453,321	212,045	698,775	1,364,141	2,682,709	2,818,202	$2,767,664 40	$1,094,071 09	$619,824 21	$4,481,559 70
Total pick mined coal	....	....	....	....	1,998,389	1,133,480	2,363,192	5,495,061	3,103,326	2,391,735	3,407,085 43	1,006,403 29	458,846 23	4,872,334 95
Grand total	3,950,271	2,205,464	4,840,237	10,995,972	....	....	....	....	5,786,035	5,209,937	$6,174,749 73	$2,100,474 38	$1,078,670 44	$9,353,894 55

TABLE

Showing by Counties the Number of Miners, Number of Outside Day and Monthly Men, Number of Inside Day and Monthly Men, Total Wages Earned by Same and the Average Wages per Employe.

BITUMINOUS MINES.

COUNTY.	Number of Miners.	Wages Paid.	Average Wages per Miner.	Number Inside Day and Monthly Men.	Wages Paid.	Average Wages per Inside Man.	Number Outside Men.	Total Wages Paid Outside Men.	Average Wages per Outside Man.
Clay	1,681	$598,791 38	$356 21	394	$208,813 46	$529 98	228	$122,966 98	$539 33
Daviess	150	60,386 24	405 91	40	20,896 93	522 17	26	13,266 77	510 26
Fountain	92	47,231 56	513 39	20	12,694 65	634 73	11	8,484 33	771 30
Greene	2,569	1,174,221 45	457 07	771	424,886 82	551 10	267	198,580 81	743 75
Gibson	130	60,630 23	466 39	38	18,237 95	479 95	19	13,851 06	729 00
Knox	286	121,234 75	423 89	66	38,283 79	580 06	61	30,162 16	494 46
Parke	1,189	501,011 56	421 37	344	183,105 57	532 28	130	90,319 73	694 77
Perry	15	5,121 42	341 43	3	1,641 15	547 05	3	1,142 50	380 83
Pike	551	218,791 30	397 08	134	64,259 34	479 55	70	30,860 77	440 85
Sullivan	2,659	1,180,455 04	443 98	826	462,642 39	535 84	394	293,556 98	745 07
Vanderburgh	291	182,374 40	626 72	67	48,967 13	730 85	58	40,237 57	693 75
Vermillion	1,173	802,851 89	684 53	299	240,136 68	836 58	97	65,813 72	678 49
Vigo	2,232	1,074,064 62	481 21	553	338,698 28	612 49	244	148,343 29	607 96
Warrick	311	147,083 89	472 94	68	37,210 14	547 21	49	21,084 37	430 29
General average	13,329	$6,174,749 73	$463 26	3,623	$2,100,474 38	579 76	1,657	$1,078,670 44	$650 98

TABLE

Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, Persons Employed Outside; Total Number of Employes at Each Mine, Number of Days Worked and Number of Mules Used; Totals by Counties; Expenditures for Improvements.

CLAY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Brazil Block No. 1	......	6	22	20	6	54	271	9	....
Brazil Block No. 4	75	......	......	22	22	119	190	4	....
Brazil Block No. 8	24	......	......	14	7	45	184	7	....
Gart No. 7	88	......	......	15	9	112	192	8	....
Continental No. 1	12	......	......	13	3	18	200	1	....
Rebstock	50	......	......	9	6	65	125	3	....
Vandalia No. 64	51	......	......	12	8	71	206	7	....
Vandalia No. 65	92	......	......	10	8	110	183	6	....
Superior No. 4	38	......	......	12	5	55	153	3	....
Superior No. 7	36	......	......	14	5	55	207	6	....
Vandalia No. 60	Idle.	......	......	......	......	......	......	...	....
Vandalia No. 63	70	......	......	18	8	96	92	7	....
Cornwall	39	......	......	6	3	48	144	3	....
Crawford No. 4	43	......	......	8	6	57	173	3	....
Crawford No. 5	30	......	......	5	4	39	22	2	....
Crawford No. 8	42	......	......	5	4	51	10	2	....
Crawford No. 9	37	......	......	6	4	47	190	3	....
Fortner	33	......	......	9	4	46	85	2	....
Gifford No. 1	30	6	32	16	8	92	172	7	....
Gifford No. 2	80	6	27	34	9	156	88	10	$1,344 72
Glenn No. 1	45	......	......	9	6	60	123	3	....
Glenn No. 2	23	......	......	3	4	30	143	...	....
Monarch	12	......	......	7	2	21	251	2	....
Lewis	4	12	40	11	10	77	155	4	....
Vivian No. 2	22	18	60	20	12	132	225	7	553 52
Vivian No. 1	6	12	45	12	10	85	193	8	127 25
Indiana Block	36	......	......	12	5	53	15	4	....
Gold Knob	7	10	36	11	11	75	178	4	2,215 09
World's Fair No. 2	25	......	......	6	4	35	167	2	75 00
Brazil Block No. 9	44	......	......	22	7	73	7	6	....
Crawford No. 6	118	......	......	17	8	143	171	8	....
Vandalia No. 50	36	......	......	7	5	48	180	2	1,191 10
Eureka No. 5	45	......	......	6	6	57	115	2	2,264 35
Island Valley No. 4	......	10	46	13	9	78	74	8	....
Total	1,293	80	308	394	228	2,303	4,884	153	$7,771 03

DAVIESS COUNTY.

Stuckey	7	......	......	1	2	10	22	....	$80 50
Montgomery No. 3	58	......	......	20	13	91	204	11	....
Mutual	71	......	......	17	8	96	175	9	815 00
Mandabach	14	......	......	2	3	19	140	2	....
Total	150	......	......	40	26	216	541	22	$895 50

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.

FOUNTAIN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Rush	55	......	......	11	6	72	179	5	$365 00
Silverwood	37	......	......	9	5	51	231	4	....
Total	92	......	......	20	11	123	410	9	$365 00

GIBSON COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Oswald	56	......	......	21	9	86	105	10	....
Massey	57	......	......	12	5	74	210	8	$500 00
Fort Branch	17	......	......	5	5	27	220	1	225 00
Total	130	......	......	38	19	187	535	19	$725 00

GREENE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Black Creek	57	8	40	25	9	139	126	13	....
Vandalia No. 2	82	14	27	50	13	186	124	19	$2,527 71
Vandalia No. 5	47	16	34	50	14	161	125	20	6,811 67
Vandalia No. 6	36	......	......	12	5	53	143	7	551 40
Vandalia No. 4	39	......	......	13	6	58	171	4	1,682 57
Gilmour	26	18	114	58	17	233	151	25	....
Hoosier No. 1	2	10	41	27	6	86	224	7	....
Hoosier No. 2	25	......	......	4	4	33	33	2	....
Vandalia No. 21	......	14	34	8	10	66	129	3	....
Island Valley No. 3	84	......	......	24	11	119	49	17	....
Vandalia No. 3	133	......	......	28	10	171	152	17	5,485 64
Midland	2	10	42	33	11	98	147	6	....
Vulcan	35	......	......	5	7	47	20	3	....
Summitt No. 2	14	18	91	55	10	188	182	21	....
Victoria	202	......	......	51	17	270	244	21	....
Glenburn	61	4	18	26	6	115	82	10	....
Antioch	81	......	......	31	13	125	215	10	....
Tower Hill	138	6	38	11	8	201	103	6	....
Green Valley	1	18	100	37	11	167	116	13	652 79
Lattis Creek	32	20	110	63	20	245	189	24	....
Vandalia No. 8	23	20	100	40	12	195	179	18	4,434 53
Vandalia No. 9	10	20	140	34	12	216	76	21	3,944 37
Twin	......	20	92	17	10	139	184	8	....
North Linton	84	......	......	31	8	123	101	9	....
Pennsylvania	28	......	......	6	6	40	157	3	500 00
North Western	9	10	71	32	11	133	72	10	....
Total	1,251	226	1,092	771	267	3,607	3,494	317	$26,590 68

KNOX COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Bicknell	53	......	......	13	9	75	111	8	....
Knox	68	......	......	18	9	95	193	9	....
Lynn	1	4	18	7	8	38	80	3	$128 60
Vandalia No. 40	23	4	27	8	6	68	72	3	1,601 78
Wheatland	51	......	......	9	7	67	205	4	....
Pine Knot	......	10	27	11	22	70	182	4	900 00
Total	196	18	72	66	61	413	843	31	$2,629 78

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
PARKE COUNTY.									
Brazil Block No. 12	40	4	7	16	3	70	159	6	....
Cox No. 3	67	......	......	16	13	96	158	7	....
Brazil Block No. 9	71	......	......	23	7	101	163	6	....
Lucia	50	......	......	13	6	69	50	11	$300 00
Mecca No. 3	77	6	33	32	13	161	191	16	500 00
Lyford No. 1	44	8	18	20	9	99	185	8	....
Mary	5	16	48	33	12	114	181	9	....
Superior No. 1	112	......	......	30	7	149	175	12	....
Superior No. 2	110	......	......	38	11	159	213	12	....
Superior No. 3	65	......	......	12	6	83	98	3	....
Minshall No. 1	109	......	......	45	12	166	130	15	3,037 80
Minshall No. 2	81	......	......	15	7	103	184	6	3,085 28
Pan American	70	......	......	15	10	95	209	6	....
Parke No. 11	21	28	48	20	11	128	207	9	....
Harrison	40	4	7	16	3	70	159	....	....
Total	962	66	161	344	130	1,663	2,462	126	$6,923 08
PERRY COUNTY.									
Troy	15	......	......	3	3	21	211	2	....
Total	15	......	......	3	3	21	211	2	....
PIKE COUNTY.									
Aberdeen	16	......	......	3	3	22	26	2	....
Carbon	40	......	......	12	8	60	212	12	....
Ayrshire No. 3	72	......	......	20	7	90	201	15	$32,234 95
Ayrshire No. 4	118	......	......	31	12	161	205	13	....
Ayrshire No. 5	25	......	......	3	3	31	110	3	....
Rogers	17	......	......	5	5	27	220	1	....
Blackburn	27	......	......	6	5	38	33	3	....
Littles	137	......	......	31	14	182	143	13	....
Hartwell	99	......	......	23	13	135	182	13	....
Petersburg	Idle.								
Winslow No. 2	Idle.								
Winslow No. 5	Idle.								
Total	551	......	......	134	70	755	1,332	75	$32,234 95

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.

SULLIVAN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Bunker Hill	26	8	38	34	18	124	144	10	....
Caladonia	5	14	72	34	12	137	73	10	....
Dugger	3	10	90	28	12	143	93	7	$1,500 00
Consolidated No. 32	5	22	114	41	10	192	190	11	4,955 34
Consolidated No. 33	5	20	102	37	15	179	202	10	6,808 12
Consolidated No. 34	......	10	35	23	10	78	233	4	4,403 87
New Linton	3	6	30	17	7	63	68	6	....
Jackson Hill No. 2	......	20	112	33	15	180	181	15	....
Jackson Hill No. 4	47	12	63	18	12	152	235	7	542 00
Phoenix No. 4	2	10	61	30	18	121	164	11	....
Shelburn	5	8	12	24	7	36	139	11	....
Consolidated No. 29	7	14	65	45	18	149	180	15	6,554 18
Consolidated No. 31	49	......	......	13	6	68	133	6	71 69
Freeman	58	......	......	10	7	75	101	6	....
Sun Flower	......	16	92	27	12	147	167	11	....
Consolidated No. 26	1	16	88	42	14	161	207	13	1,921 78
Dering No. 14	2	16	96	50	25	189	180	16	....
Vandalia No. 10	90	......	......	20	13	123	165	7	2,872 20
Semi-Block	3	8	36	28	11	86	183	3	....
Mammoth Vein	2	16	70	18	13	119	95	8	....
Shirley Hill	28	12	40	11	7	98	228	5	....
Cummins	68	......	......	26	10	104	160	12	....
Hocking	18	22	86	39	14	179	184	14	....
Citizens	......	4	14	17	7	32	135	2	3,700 00
Dering No. 12	69	......	......	23	9	101	175	8	....
Dering No. 13	24	12	44	17	10	107	223	8	289 20
Consolidated No. 28	10	12	54	19	13	108	161	7	605 80
Superior	76	......	......	18	8	102	142	5	962 00
Consolidated No. 30	......	10	45	15	12	82	159	4	4,414 10
Pearl	10	8	33	8	7	66	166	4	150 00
Reliance	......	6	22	17	18	53	123	3	1,726 03
Union	......	8	31	32	12	83	120	3	8,957 92
Hamilton	Idle								
Little Giant	43	14	64	29	10	160	229	8	....
Black Hawk	12	6	15	7	6	46	188	2	....
Clover Leaf	......	4	20	6	6	36	106	2	....
Total	671	344	1,644	826	394	3,879	5,632	274	$50,434 23

VANDERBURGH COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Diamond	35	......	......	7	8	50	222	4	....
First Avenue	27	......	......	4	9	40	261	3	....
Ingleside	51	......	......	10	10	71	308	8	....
Sunnyside	53	......	......	16	12	81	139	12	....
Union	33	......	......	8	7	48	215	5	....
Unity	92	......	......	22	12	126	232	15	....
Total	291	......	......	67	58	416	1,377	47	....

VERMILLION COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Dering No. 7	140	......	......	35	9	184	195	18	....
Dering No. 5	152	......	......	51	12	215	222	24	....
Dering No. 6	85	......	......	25	8	118	296	8	....
Eureka	20	......	......	5	3	28	198	3	$235 50
Buckeye No. 2	Not	repo	rted.						
Crown Hill No. 1	96	......	......	20	7	123	176	11	5,110 00
Crown Hill No. 2	122	......	......	18	8	148	167	10	3,605 00
Oak Hill	132	......	......	34	11	177	198	15	....
Prince	154	......	......	48	13	215	234	14	2,069 10
Dering No. 15	82	......	......	15	8	105	195	9	....
Dering No. 8	120	......	......	31	10	161	238	15	....
Maple Valley	70	......	......	17	8	95	189	8	....
Total	1,173	......	......	299	97	1,569	2,308	135	$11,019 60

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.

VIGO COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Atherton	9	12	50	19	10	100	174	7	....
Chicago No. 6	118	......	......	16	8	142	111	6	....
Diamond	115	......	......	37	12	164	214	17	....
Peerless	37	......	......	9	6	52	209	4	....
Lawton	190	......	......	33	14	237	227	19	....
Seeleyville. Idle.									
Grant No. 2	157	......	......	61	13	231	224	23	$1,000 00
Glen Oak No. 9	......	16	88	50	15	169	206	....	....
Vandalia No. 68	38	......	......	14	10	62	55	8	155 10
Klondike No. 10	90	......	......	22	12	124	190	....	....
Miami No. 1	190	......	......	35	10	235	94	18	....
Miami No. 2	90	......	......	13	8	111	166	9	....
Miami No. 3	102	......	......	17	8	127	196	6	....
Parke No. 10	54	16	33	39	15	157	178	13	....
Redbird	45	......	......	12	7	64	230	6	....
Vandalia No. 67	173	......	......	33	12	218	141	14	2,413 03
Vandalia No. 66	80	......	......	20	13	113	162	8	2,384 19
Vandalia No. 81	72	......	......	14	12	98	185	8	1,146 32
Deep Vein	65	......	......	18	9	92	212	6	1,725 00
Vandalia No. 80	59	......	......	25	6	90	153	6	1,109 03
Vandalia No. 69	64	......	......	16	8	88	202	8	2,110 57
Vandalia No. 82	56	12	12	12	7	99	225	4	1,750 23
Ray No. 2	64	12	23	12	9	120	210	5	....
Forrest Park	......	20	37	19	12	88	184	5	....
Domestic Block	33	......	......	7	8	48	104	2	1,595 65
Total	1,901	88	243	553	244	3,029	4,252	202	$15,389 12

WARRICK COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Improvements.
Big Four	11	12	36	12	9	80	219	7	$859 55
Big Vein No. 3	8	18	54	13	9	102	204	8	....
Chandler	......	8	16	4	4	32	100	2	....
De Forrest	......	4	10	3	3	20	73	2	....
Star No. 1	44	......	......	9	8	61	75	8	....
Electric	......	12	57	23	11	103	221	10	....
Burke	21	......	......	4	5	30	104	2	....
Total	84	54	173	68	49	428	996	39	$859 55

TABLE

Showing Comparative Statement of Coal Produced, Number of Employes, Wages Paid and Per Cent. Increase and Decrease for Each Year from 1900 to 1905, Inclusive.

YEAR.	Employes.	Per Cent. Increase.	Per Cent. Decrease.	Tons Produced.	Per Cent. Increase.	Per Cent. Decrease.	Wages Paid.	Per Cent. Increase.	Per Cent. Decrease.
1901 over 1900......	12,096	22	......	7,019,203	11	....	$5,680,539 86	17	......
1902...............	13,139	.08	......	8,763,197	24	....	7,078,913 12	24	......
1903...............	15,128	15	......	9,992,553	14	....	9,149,572 12	29	......
1904...............	17,838	17	......	9,872,404	......	.01	9,165,404 38	.01 10	......
1905...............	18,609	.043	......	10,995,972	11	....	9,353,894 55	.02	......

TABLE

Showing a Comparison of Average Wages Earned by Miners, Inside Day and Monthly Men and by Outside Day and Monthly Men from 1901 to 1905, Inclusive.

YEAR.	Miners.	Inside Day and Monthly Men.	Outside Day and Monthly Men.
1901..................	$436 29	$544 47	$593 24
1902..................	500 27	642 46	631 85
1903..................	566 14	699 67	689 54
1904..................	450 30	631 38	609 36
1905..................	463 26	579 36	650 98

NOTE.—In 1904 the block coal miners' wages were separated from the bituminous, while in the above table the block coal and bituminous wages are combined.

MINING MACHINERY.

We exhibit in the 6 following tables the number of steam boilers, number of hoisting engines, number of dynamos, number of compressors, number of automatic cages, number of shaker screens, number of box car loaders, number of coal washers, number of mines having rope haulage, number of mine motors, number of electric chain mining machines and the number of compressed air punching machines now in use at Indiana mines. Also an estimated cost of the various kinds of machinery.

TABLE

Of Steam Boilers and Hoisting Engines.

COUNTY.	Steam Boilers.				Hoisting Engines.		
	Tubular Boilers	Flued Boilers.	Cylinder Boilers.	Total.	Direct.	Geared.	Total.
Clay	34	4	16	54	8	29	34
Daviess	......	.....	8	8	......	4	4
Fountain	......	.....	3	3	......	2	2
Greene	53	10	4	67	22	7	29
Gibson	5	......	......	5	1	2	3
Knox	3	1	.....	4	3	4	7
Parke	11	4	7	22	5	8	13
Perry	......	1	......	1	......	1	1
Pike	4	4	......	8	......	7	7
Sullivan	91	2	4	97	24	12	36
Vanderburgh	6	10	......	16	3	3	6
Vermillion	24	4	......	28	11	1	12
Vigo	32	12	17	61	12	13	25
Warrick	6	5	......	11	......	8	8
Total	269	57	59	385	89	101	190

Total estimated cost of tubular boilers	$196,185 00	
Total estimated cost of flued boilers	22,200 00	
Total estimated cost of cylinder boilers	17,000 00	
Total estimated cost of all kinds of boilers		$235,385 00
Total estimated cost of direct hoisting engines	$156,350 00	
Total estimated cost of geared hoisting engines	87,500 00	
Total estimated cost of all kinds of engines		$243,850 00
Total estimated cost of engines and boilers		$479,235 00

TABLE

Showing by Counties the Number of Dynamos in Use and Names of Manufacturers.

COUNTY.	Goodman.	Jeffrey.	Morgan Gardner.	Link Belt.	General Electric.	Jenny.	Kester.	Ridgeway.	Thompson & Ryan.	Walker.	Independent.	Coker & Wheeler.	Milwaukee Electric Co.	Ideal.	Western Electric Co.	Total.
Clay	....	1	5	2	....	....	....	....	....	1	1	....	....	....	....	10
Greene	7	5	6	2	1	1	....	....	....	....	....	....	....	....	....	22
Knox	....	....	....	....	1	....	....	....	....	....	....	1	....	....	....	2
Parke	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....	2
Pike	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	2
Sullivan	6	6	13	....	....	1	1	1	4	....	....	....	1	1	1	35
Vermillion	1	....	2	....	....	....	....	....	....	....	....	....	....	....	....	3
Vigo	1	....	5	1	....	....	1	....	....	....	....	....	....	....	....	8
Warrick	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Tôtal	15	14	34	5	2	2	2	1	4	1	1	1	1	1	1	85

Estimated cost of dynamos f. o. b. factory..........$153,000 00
The above number of dynamos will require the same number of steam engines to drive them, the estimated cost of which will be 136,000 00

Total estimated cost of dynamos and engines..........$289,000 00

TABLE

Showing Number and Kind of Mining Machines and Compressors; Also Names of Manufacturers of Same.

COUNTY.	Electric Chain Machines.							Compressed Air Punchers				Air Compressors.				
	Morgan Gardner.	Jeffrey.	Link Belt.	Goodman.	Morgan Standard.	Sullivan.	Total.	Harrison.	Ingersol-Sargent.	Sullivan.	Total.	Norwalk.	Sullivan.	Ingersol-Sargent.	Allison.	Total.
Clay	30	9	....	....	3	....	42	....	6	....	6	....	....	1	....	1
Greene	32	39	18	17	4	2	112	37	2	9	48	5	1	....	....	6
Knox	....	4	....	....	....	3	7	1	2	....	3	....	....	1	....	1
Parke	12	....	....	....	....	....	12	....	....	14	14	2	....	....	....	2
Pike	1	....	....	....	....	....	1	1	....	....	1	....	....	1	....	1
Sullivan	114	15	16	30	....	....	175	21	..	....	21	2	....	....	....	2
Vanderburgh	....	....	....	....	....	....	....	2	..	....	2	2	....	....	....	2
Vigo	16	....	....	3	....	....	19	25	1	14	40	3	1	1	1	6
Warrick	4	2	....	....	....	....	6	4	7	12	23	2	2	....	....	4
Total	209	69	31	50	7	5	374	91	18	49	158	16	4	4	1	25

Estimated cost electric chain machines f. o. b. factory..........$411,400 00
Estimated cost compressed air puncher machines f. o. b. factory.......... 46,400 00
Estimated value compressors f. o. b. factory 75,000 00

Total estimated cost machines and compressors..........$532,800 00

TABLE

Showing by Counties the Number of Shaker Screens and Automatic Cages in Use, Also Names of Manufacturers.

COUNTY.	Shaker Screens.										Automatic Cages.					
	George Parker.	Prox & Brinkman	Duncan Bros.	S. W. Little.	Schuttig Steel & Iron Works.	Powell.	George Ingle.	Jeffrey.	Home Made.	Total.	George Parker.	Prox & Brinkman	Duncan Bros.	Halbert.	John Gilmore.	Total.
Clay	3	....	1	....	....	....	....	....	....	4	14	14	....	....	....	28
Greene	8	....	....	....	....	....	1	....	..	9	24	12	....	4	2	42
Gibson	....	....	....	....	....	....	....	....	2	2	8	....	....	....	2	10
Knox	1	....	...	...	1	....	1	....	....	3	8	2	....	2	....	12
Parke	....	....	....	....	....	....	....	....	....	....	4	14	....	....	....	18
Pike	....	....	1	2	....	1	....	....	1	5	2	2	....	....	....	4
Sullivan	7	3	2	....	....	....	1	1	....	14	36	26	4	2	....	68
Vermillion	1	2	....	....	....	....	....	....	....	3	8	12	....	....	....	20
Vigo	1	....	1	....	....	....	....	....	....	2	26	10	....	....	....	36
Warrick	....	....	....	....	....	....	....	....	....	....	4	2	....	....	....	6
Total	21	5	5	2	1	1	3	1	3	42	134	94	4	8	4	244

Total estimated value of shaker screens	**$63,000 00**
Total estimated cost of automatic cages	**73,200 00**
Total estimated cost of cages and screens	**$136,200 00**

TABLE

Box Car Loaders and Coal Washers.

COUNTY.	Box Car Loaders and Name of Manufacturers.				Coal Washers.
	Autumwa.	Christy.	Victor.	Total.	Link Belt.
Clay	3	......	1	4	....
Greene	3	1	......	4	....
Parke	1	......	......	1	....
Pike	......	1	......	1	1
Sullivan	11	2	......	13	....
Vermillion	2	1	......	3	....
Total	20	5	1	26	1

Total estimated cost of box car loaders installed	**$65,000 00**
Total estimated cost of coal washers	**6,000 00**
Total estimated cost of loaders and washers	**$71,000 00**

TABLE

Of Mine Haulage by Counties.

COUNTY.	Traction Motors.					Third Rail Motors.			Total Number All Kinds of Motors.	Tail Rope.
	General Electric.	Morgan Gardner.	Jeffrey Mfg. Co.	Goodman.	Total.	Friction Clutch, Morgan Electric Co.	Third Rail Sprocket, Morgan Electric Co.	Total.		
Clay	......	2	1	......	3	1	......	1	4	......
Greene	......	1	2	5	8	......	1	1	9	1
Parke	......	......	......	......	......	......	......	......	......	1
Pike	......	......	1	......	1	......	1	1	2	1
Sullivan	...	3	2	......	5	......	5	5	10	1
Vermillion	2	......	......	2	4	......	......	......	4	1
Vigo	......	2	......	......	2	......	3	3	5	2
Totals	2	8	6	7	23	1	10	11	34	7

Total estimated cost of motors f. o. b. factory	$58,400 00
Total estimated cost of rope-haulage plants, complete, including engine, ropes, sheaves, labor, etc	28,000 00
Total estimated cost of motors and rope-haulage	$86,400 00

SUMMARY OF MINING MACHINERY.

Total number of direct hoisting engines	89
Total number of geared hoisting engines	101
Grand total number of hoisting engines	190
Total estimated cost of direct hoisting engines	$156,350 00
Total estimated cost of geared hoisting engines	87,500 00
Grand total estimated cost of hoisting engines	243,850 00
Total number of tubular boilers	269
Total number of flued boilers	57
Total number of cylinder boilers	59
Grand total number of boilers	385
Total estimated cost of tubular boilers	$196,185 00
Total estimated cost flued boilers	22,200 00
Total estimated cost cylinder boilers	17,000 00
Grand total estimated cost of boilers	235,385 00
Grand total hoisting engines and boilers	479,235 00
Total number shaker screens	42
Total estimated cost shaker screens	$63,000 00
Total number automatic cages	244
Total estimated cost automatic cages	$73,200 00
Total number box car loaders	26
Total estimated cost box car loaders	$65,000 00
Total number coal washers	1
Cost of coal washer	$6,000 00

ELECTRIC MACHINERY.

Total number of dynamo engines	85
Total number of dynamos	85
Total number of chain mining machines	374
Total number of mine motors	34
Total estimated cost of dynamo engines	$136,000 00
Total estimated cost of dynamos	153,000 00
Total estimated cost of chain mining machines	411,400 00
Total estimated cost of mine motors	58,400 00
Grand total estimated cost electrical machinery	758,800 00
Total number of mines having rope haulage	7
Total estimated cost of rope haulage	$28,000 00

COMPRESSED AIR MACHINERY.

Total number of compressors	25
Total number compressed air punching machines	158
Total estimated cost of compressors	$75,000 00
Total estimated cost punching machines	46,400 00
Grand total estimated cost compressed air machinery	121,400 00

RECAPITULATION.

Total estimated cost of hoisting engines	$243,850 00
Total estimated cost of steam boilers	235,385 00
Total estimated cost of automatic cages	73,200 00
Total estimated cost of box car loaders	65,000 00
Total estimated cost of coal washers	6,000 00
Total estimated cost of electrical machinery	758,800 00
Total estimated cost of rope haulage	28,000 00
Total estimated cost of compressed air machinery	121,000 00
Grand total	$1,531,235 00

Note 1. There are no electric hoisting engines at any of the Indiana mines.

Note 2. The above, while representing the important parts of machinery, cost, etc., that make up the complement of a mine, does not represent by far the actual amount expended in opening and developing a mine. To this must be added the sinking and timbering of shaft, tipple, engine room, boiler room and other buildings ventilating fan, scales, ropes, blacksmith shop, smithing tools, mine cars, mine pumps, mine mules, railroad switch and many other articles all of which would amount to a sum about equal to that represented in the recapitulation.

TABLE

Showing names of mines in which mining is done with mining machines, also number of Loaders, Machine Runners and Helpers and Average Tons Per Machine and Per Loader and Number of Days Worked.

BLOCK COAL MINES.

CLAY COUNTY.

Name of Mine.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Brazil Block No. 1	3	......	31,471	22	6	1,748	10,490	271
Brazil Block No. 8	4	......	2,253	15	8	150	563	16
Total	7	......	33,724	37	14	913	4,817	143

PARKE COUNTY.

Name of Mine.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Brazil Block No. 12	2	......	285	7	4	40	142	8
Mary	8	......	41,064	48	16	855	5,120	181
Total	10	......	41,349	55	20	757	4,131	94

BITUMINOUS MACHINE MINES.

CLAY COUNTY.

Name of Mine.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Gifford No. 1	3	......	30,554	32	6	954	4,349	172
Gifford No. 2	3	......	9,702	27	6	359	3,418	70
Lewis	......	6	68,732	56	12	1,227	11,455	155
Vivian No. 4	9	......	54,782	60	18	913	6,086	225
Vivian No. 5	6	......	10,972	45	12	243	1,828	87
Gold Knob	5	......	47,519	36	......	1,319	9,503	178
Total	26	6	222,261	256	54	869	6,945	177

GREENE COUNTY.

Name of Mine.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Black Creek	4	......	57,509	40	8	1,437	14,375	126
Vandalia No. 2	......	7	35,173	27	14	1,302	5,025	124
Vandalia No. 5	......	8	69,021	34	16	2,030	8,627	125
Gilmour	9	......	103,229	114	18	905	11,469	151
Hoosier No. 1	5	......	61,944	41	10	1,510	12,388	224
Island Valley No. 2	......	7	34,121	34	14	1,003	4,874	129
Midland	5	......	55,601	42	10	1,323	11,120	147
Summitt No. 2	9	......	137,733	91	18	1,513	15,303	182
Glenburn	4	.....	15,621	18	8	867	3,905	82
Antioch	1	......	820	8	2	102	820	10
Tower Hill	3	......	30,491	38	6	802	10,163	103
Green Valley	9	......	110,207	100	18	1,102	12,215	116
Lattas Creek	10	......	210,698	110	20	1,915	27,069	189
Atlas No. 1	10	......	138,824	100	20	1,388	13,882	179
Atlas No. 2	10	......	9,691	140	20	69	969	30
Letsinger	......	4	4,309	20	8	215	1,077	37
Twin	10	......	151,615	92	20	1,648	15,161	184
North West	5	......	49,573	71	10	698	9,914	72
Total	94	26	1,276,173	1,120	308	1,139	10,634	122

Note.—Employes in the Letsinger and Antioch mines are not shown in table of employes.

KNOX COUNTY.

Name of Mine.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Lynn	2	.....	12,764	18	4	709	6,382	80
Pine Knot	5	.....	21,618	37	10	584	4,323	182
Enterprise	.....	2	1,512	27	4	56	756	27
Total	7	2	35,894	82	18	437	3,988	96

PARKE COUNTY.

Name of Mine.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Mecca No. 3	3	......	3,989	33	6	1,211	13,329	191
Lyford No. 1	4	......	9,790	18	8	544	2,447	52
Parke No. 11	......	14	92,456	48	28	1,924	6,604	150
Total	7	14	142,235	99	42	1,436	6,773	450

SULLIVAN COUNTY.

Name of Mine.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Bunker Hill	4	......	33,726	38	8	887	8,431	124
Caledonia	7	......	21,191	72	14	294	3,027	52
Vandalia No. 30	5	......	25,210	90	10	280	5,042	93
Consolidated Southern Ind. No. 32	11	......	101,179	104	22	972	9,198	190
Consolidated Southern Ind. No. 33	10	......	149,444	102	20	1,465	14,944	202
Consolidated Southern Ind. No. 34	5	......	59,971	35	10	1,713	11,994	233
Consolidated Southern Ind. No. 29	7	......	96,232	65	14	1,480	13,747	180
Consolidated Southern Ind. No. 31	No re	port.	2,750	Mac	hines	not re	ported.	20
Consolidated Southern Ind. No. 26	8	......	52,222	88	16	593	6,527	207
Consolidated Southern Ind. No. 28	6	......	101,525	54	12	1,880	16,920	161
Consolidated Southern Ind. No. 30	5	......	39,803	45	10	884	7,960	159
Consolidated Southern Ind. No. 25	4	......	21,691	31	8	699	5,422	120
New Linton	3	......	12,530	30	6	415	4,176	68
Jackson Hill No. 2	10	......	148,155	112	20	1,322	14,815	181
Jackson Hill No. 4	6	......	24,175	63	12	383	4,029	68
Phoenix No. 4	5	......	38,349	61	10	628	7,669	164
Shelburn	4	......	7,400	12	8	616	1,850	139
Sunflower	8	......	133,324	92	16	1,449	16,665	167
Dering No. 13	6	......	85,381	44	12	1,917	14,230	223
Dering No. 14	8	......	161,888	96	16	1,694	20,236	180
Wolford	4	......	36,197	36	8	1,005	9,049	183
Mammoth	8	......	26,765	70	16	3,382	3,345	95
Shirley Hill No. 1	6	......	59,888	40	12	1,497	9,999	141
Cummins	......	......	13,264	Mac	hines	taken	out.	
Hocking	11	......	149,601	86	22	1,739	13,600	184
Citizens	2	......	9,888	14	4	706	4,944	135
Kettle Creek	4	......	33,466	33	8	1,014	8,366	166
Reliance	3	......	17,053	22	6	775	5,684	123
Little Giant	7	......	125,361	64	14	1,958	17,908	229
Black Hawk	3	......	12,865	15	16	857	4,288	188
Clover Leaf	2	......	6,519	20	4	325	3,259	60
Total	172	......	1,807,013	1,634	344	1,106	10,505	147

VIGO COUNTY.

Name of Mine.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Atherton	6	......	59,486	50	12	1,189	9,914	174
Parke No. 10		13	104,143	33	26	3,155	8,011	178
Vandalia No. 82	6	......	20,666	12	12	1,722	3,444	212
Ray No. 2	6	......	21,779	23	12	946	3,629	210
Forrest Park	......	10	35,652	37	20	966	3,565	184
Klondike	......	......	798	Mac	hines	taken	out.	
Total	18	23	242,521	135	82	1,055	5,915	191

WARRICK COUNTY.

NAME OF MINE.	Electric Chain.	Comp. Air Puncher.	Total Tons Produced.	Loaders.	Machine Runners and Helpers.	Average Tons per Loader.	Average Tons per Machine.	Days Worked.
Big Four	......	6	57,801	36	12	1,605	9,633	219
Big Vein	.....	9	95,606	54	18	1,770	10,622	204
Chandler	......	4	25,819	16	8	1,613	6,454	100
De Forrest	......	2	6,280	10	4	628	3,141	73
Electric	6	0	122,409	57	12	2,147	20,401	221
Caledonia	0	3	not rep'd	12	6	....	....	....
Total	6	24	307,915	185	60	1,664	10,263	163

NOTE. See General Table for Cummins, Consolidated Southern Indiana No. 31, Klondike

TABLE

Showing the Number of Tons of Coal produced in each County, the Number of Kegs of Powder used, Number of Tons of Cool produced per each Keg and the Total production for the State for the year 1905 and a general average of Tons produced per Keg of Powder.

County.	Total Tons of Coal.	No. Kegs of Powder.	Tons per Keg.
Clay	815,860	22,457	25.1
Daviess	76,653	3,921	19 5
Fountain	70,535	4,231	16.6
Greene	2,216,190	53,601	41.9
Gibson	100,847	4,674	21.1
Knox	223,964	11 993	18.6
Parke	741,013	29,327	25.2
Perry	7,895	443	17.8
Pike	388,845	18,307	21.2
Sullivan	2,395,918	45,333	52.8
Vanderburgh	307,781	13,886	22.1
Vermillion	1,381,246	87,939	15.7
Vigo	1,898,617	73,443	25.8
Warrick	340,608	5,895	57.7
Grand Total	10,995,972	427,650	25.7

NOTE. 1. The price paid for powder during the year was one dollar and seventy-five cents ($1.75) per keg, which represents a total sum of seven hundred and forty-eight thousand three hundred and eighty-seven dollars and fifty cents ($748,387.50) or a fraction over six and eight tenths (6.8 cents per ton for each ton of coal prcduced.

NOTE. 2. Mining in Daviess, Fountain, Gibson, Perry, Pike, Vanderburgh and Vermillion Counties is done by hand exclusively. By referring to the above table it will be seen that the average tons of coal produced per keg of powder in these counties is far below the general average for the state. It will also be noticed that the averages in Greene, Sullivan and Warrick Counties are very high; this is accounted for by reason of the fact that the greater portion of coal mined in these three counties is done with machines.

TABLE

Showing by Counties the Geological Number of coal seams operated in the Bituminous Coal fields of Indiana and the Number of Tons mined from each seam in 1905.

Geological Number of Seams and Number of Tons Mined.							Total.
County.	II.	III.	IV.	V.	VI.	VII.	
Clay		139,643	99,859	71,640	163,054		474,196
Daviess		26,605		50,048			76,653
Fountain		71,090					71,090
Greene		128,275	1,972,556	114,166			2,214,997
Gibson				81,987	18,959		100,946
Knox				18,560	152,698	52,706	223,964
Parke		244,729	12,822		207,523		465,074
Pike				388,847			388,847
Perry	7,895						7,895
Sullivan		114,196	100,163	302,557	1,719,260	151,503	2,387,679
Vandorburgh				307,781			307,781
Vermillion						1,384,682	1,384,682
Vigo					1,824,475	68,350	1,892,825
Warrick				340,608			340,608
Total	7,895	724,538	2,185,400	1,689,016	4,086,369	1,657,241	10,337,237

EXAMINATIONS.

Examinations of applicants for certificates of competency to serve as mine boss, fire boss and hoisting engineers were held in Terre Haute on the following dates during the year 1905, and the result of each examination exhibited in the table below:

	Applicants.			Passed.			Failed.		
	M. B.	F. B.	H. E.	M. B.	F. B.	H. E.	M. B.	F. B.	H. E.
April 11 to 13	47	8	55	25	5	23	22	3	32
August 23, 24, 25	35	8	24	24	1	10	11	7	14
December 27, 28	37	24	35	27	18	23	12	6	12
Total	119	40	114	74	24	56	45	16	58

We give herewith a list of the names and addresses of persons who passed at the above examinations and to whom certificates were granted, also number of certificate and per cent. of grade:

HOISTING ENGINEERS.

Examination Held April 11, 12 and 13, 1905.

No. Certificate.	Name.	Address.	Per Cent.
7	Wm. H. Southerlin	Carlisle	79
8	Lon Wilson	Carlisle	78
9	Hershel Wence	Shelburn	80
10	Isaac Kauble	Linton	76

No. Certificate.	Name.	Address.	Per Cent.
11	J. N. Arthur	Gilmour	76
15	John Strietelmier	Linton	75
17	Frank Gambill	Sullivan	77
18	George A. Gastinean	Sullivan	77
22	Thad Miller	Seeleyville	79
31	A. M. Dale	Bicknell	77
33	Joseph Fox	Bicknell	84
63	Jas. N. Watson	Linton	78
66	Oscar L. Lind	Sandborn	83
65	W. B. Beattie	Littles	77
70	Allen Ruble	Tritchton	77
85	J. A. Baker	Coalmont	79
90	Charles Miller	Linton	77
93	Jas. C. Winn	Brazil	76
94	J. E. West	Linton	78
95	C. H. Rumbaugh	Brazil	77
99	Benj. H. Ruble	Wheatland	76
104	Albert Weaver	Bicknell	79
113	Scott Amour	Linton	76

MINE BOSS.

Examination Held April 11, 12 and 13, 1905.

No. Certificate.	Name.	Address.	Per Cent.
6	Arch Fisher	Diamond	81
25	Herbert M. Stewart	Burnett	84
26	Ambrose Johnson	Terre Haute	77
29	E. Kent Davis	Shelburn	77
32	George H. Burton	Princeton	81
36	William Treager	Brazil	84
37	James Gray	Diamond	78
39	Reuben H. Crabb	Edwards	77
42	Thomas E. Cassady	Cannelburg	82
43	John Pintin	Edwards	77
45	George Benefield	Shelburn	84
46	Oliver Houstin	Clinton	87
51	Alex Wright	Ehrmandale	79
52	Harry Harvey	Linton	79
72	T. A. Mathews	Jasonville	80
75	William Sampson	Linton	77
76	Charles E. Sherwood	Linton	86
78	John D. Harper	Linton	87
79	Stephen J. Robinett	Linton	81
91	Charles S. Perry	Cates	91
96	Otto R. Chamberlain	Seeleyville	76
24	Charles McAtee	Linton	79
106	Thomas Race	Brazil	77
108	Archie McCulloch	Clinton	82
109	L. L. Reese	Bicknell	77

FIRE BOSS.

Examination Held April 11, 12 and 13, 1905.

No. Certificate.	Name.	Address.	Per Cent.
53	Jules Surmont	Linton	80
54	Robert E. Collins	Linton	78
58	Patrick Byrne	Linton	76
82	George Murdock	Linton	76
97	W. H. Chandler	Clinton	81

HOISTING ENGINEERS.

Examination Held August 22, 23 and 24, 1905.

No. Certificate.	Name.	Address.	Per Cent.
2	John Memmert	Pleasantville	80
4	Ed A. Allen	Jasonville	76
7	Charles Beadley	Midland	78
8	Fred G. Marshall	Sullivan	81
9	Otis Ethridge	Farmersburg	78
11	W. H. Coker	Linton	78
13	William Roseberry	Farnsworth	75
14	D. E. Alumbaugh	Sullivan	75
15	Henry Ballard	Dugger	75
16	Daniel Brown	Dugger	76

MINE BOSS.

Examination Held August 23, 24 and 25, 1905.

No. Certificate.	Name.	Address.	Per Cent.
18	George W. Chambers	Clinton	90
20	Charles A. Thompson	Carbon	76
21	Urick Decker	Sullivan	85
23	W. S. Harris	Terre Haute	82
25	J. A. Crabb	Terre Haute	77
26	Robt. P. McKinney	Linton	78
27	Frank Crooks	Caladonia	80
28	Mont Ayler	Carbon	82
30	Robert T. Peel	Farmersburg	90
32	Clay Moss	Jasonville	77
33	Jules Surmont	Paxton	92
35	Edgar Livingston	Linton	76
36	Albert Wheatley	Linton	75
37	Iver Risher	Linton	80
40	Reuben Street	Terre Haute	79
42	George H. Richards	Terre Haute	76
43	Arthur Love	Linton	83
44	Scott Amour	Linton	84
45	J. F. Leigh	Linton	75
46	Oscar J. Pleschner	Linton	75
41	Noah Duchene	Brazil	76
22	Clem Phillips	Brazil	78
79	Alvah Halbert	Linton	89

HOISTING ENGINEERS.

Examination Held December 27 and 28, 1905.

No. Certificate.	Name.	Address.	Per Cent.
11	Wm. Meiring	Brazil	83
16	Charles McCarter	Shelburn	78
20	James Powell	Dugger	75
22	R. C. Lewellyn	Dugger	76
23	Charles Weaver	Sullivan	77
25	J. O. Stewart	Linton	78
27	Sherman Turvy	Linton	76
28	Garnet Gardner	Linton	77
30	Robert Baird	Cardonia	77
31	William Smith	Boonville	76
32	Harry Lewis	Princeton	90
35	Edward Jones	Linton	76
37	Ed Shott	Burnett	75
65	Alpha M. Withrow	Diamond	81

No. Certificate.	Name.	Address.	Per Cent.
66	Oscar Hall	Caladonia	89
76	George Chadwick	Fontanett	80
77	Bluford Gadberry	Shelburn	79
79	Garfield Dugger	Shelburn	76
78	Vick Vandvoir	Coal Bluff	78
83	Samuel Fleming	Carlisle	75
85	Ollie Ring	Farmersburg	93
89	J. Thomas Williams	Carlisle	79
94	George B. Russell	Burnett	89

MINE BOSS.

Examination He'd December 27 and 28, 1905.

No. Certificate.	Name.	Address.	Per Cent.
2	John J. Rowa	Farmersburg	84
5	Cooper Taylor	Jasonville	76
6	Morgan Thomas	Rosedale	90
7	Adam Vonderschmitt	Vicksburg	76
10	William Pierce	Boonville	76
12	W. L. Brown	Harmony	88
14	William Burcham	Linton	78
15	Theodore Linder	Terre Haute	76
17	P. Wiggs	Littles	79
33	Jess Thomas	Shelburn	80
41	Wm. Gregory	Cass	85
43	T. H. Mills	Shelburn	83
47	R. M. Hughes	Burnett	77
49	David Wilson	Sullivan	88
51	Charles Martin	Jasonville	76
51	John Henry	Coxville	82
54	William Anderson	Linton	87
58	William Gambill	West Terre Haute	81
61	James Kennedy	West Terre Haute	82
63	James Simons	Ayrshire	78
72	Milburn Little	Winslow	76
74	James White	Jasonville	83
75	David Evans	Coal Bluff	79
78	William Hays	Terre Haute	80
81	George Anderson	Farmersburg	86
86	Jas. Vanderver	Coal Bluff	82
98	Wm. W. Hughes	Clinton	76

FIRE BOSS.

Examination Held December 27 and 28, 1905.

No. Certificate.	Name.	Address.	Per Cent.
2	John J. Rowa	Farmersburg	84
3	Steve Robinett	Linton	79
4	Walter Lambert	Jasonville	86
40	John Sutton	Farmersburg	87
42	Clay Moss	Jasonville	85
45	Thos. Thomas	Shelburn	85
46	James Nolan	Linton	83
57	Harve Conrad	Bicknell	86
59	Sol Davis	Bicknell	80
71	John Archer	Shelburn	91
73	William Myers	Turner	87
93	R. B. Coleman	Sullivan	76
80	Uric Decker	Sullivan	80

No. Certificate.		Address.	Per Cent.
82	S. J. Wilton	Linton	82
87	James Dunn	Vicksburg	86
91	Harry Evans	Hymera	85
92	E. B. Rouse	Sullivan	83
99	William Burrows	Shelburn	99

Certificates of service granted the following in 1905:

MINE BOSS.

H. E. Hosteller	Jasonville.
Benjamin King	Seeleyville.
David Wesley	Clinton.
George B. Stuthard	Clinton.
W. F. Bosley	Troy.
Joseph Herron	Evansville.
William Seckinger	Farmersburg.
Thomas Wilson	Washington.
Martin Cahill	Cannelburg.

HOISTING ENGINEERS.

John H. Merrill	Newburgh.
Charles A. Wilder	Boonville.

MINE CASUALTIES.

The monthly reports of coal companies and mine bosses made to this office during the year 1905 show an aggregate of 251 accidents to mine employes, classified as follows: Fatal, 47; serious, 103, and minor, 101. The causes of these accidents are shown in the annexed table:

TABLE

Exhibiting Number of Casualties Arising in Indiana Mines During the Year 1905 and the Different Causes Thereof.

CAUSES OF ACCIDENT.	Fatal.	Serious.	Minor.	Total.
Falling slate	18	37	30	85
Falling coal		6	25	31
Smoke explosion	1		2	3
Delayed shots	2	6		8
Premature shots	2	2		4
Blown-out shots		7		7
Misplaced shots	9			9
Ascending cage	4			4
Decending cage		2		2
Kicked by mule		4	10	14
Mine cars	3	21	12	36
Falling down shaft	2			2
Mining machines		2	6	8
Railroad cars	1			1
Coal falling down shaft	1			1
Explosion of fire-damp	1	9		10
Shot blowing through pillar	1			1
Powder explosion	3	2		5
Miscellaneous	4		16	20
Totals	47	103	101	251

FATAL ACCIDENTS.

We give herewith, by months, a detailed statement of facts and circumstances attending each of the above fatal accidents as established by investigation made by this department, acting in conjunction with the coroner of the county in which the accident occurred, also such comments on same as we deem necessary, with recommended legislation relating to mine accidents.

JANUARY.

The records for this month show a total of 4 fatal accidents arising from different causes. The first of them occurred on the 4th inst., in the McClelland Coal Company's Buckeye Mine, Vermillion County. John Galloway, American, a shot firer, aged 26 years, met his death as the result of a smoke explosion, caused by blown out shots. Decedent and a fellow miner by the name of Charles Houser, were employed to fire the shots in this mine after the miners and other workmen had completed their day's work and left the mine. About 3:30 o'clock p. m. (firing time) of above date, they had commenced firing the shots, as usual, which had been prepared by the miners during the working hours of the mine and had completed all of their work on the north side of the mine, except one pair of cross entries, viz., the 1st and 2d northwest. Both men were lighting shots on the 2d west, Galloway commencing at the head of the entry and Houser a number of rooms farther back, each to continue lighting shots one after the other as long as there were any to light in the district allotted him. Some 8 or 10 shots had been lighted in this manner before any one of them had time to explode, when a shot located in face of the entry and one in room 4 (both resulting in blown out shots) exploded simultaneously, the flames of which entering the dense body of heated powder smoke made by the shots previously fired, caused a smoke explosion of such violence as to almost wreck the interior of the mine. The shot firers evidently feared an explosion would follow some one of the shots they had lighted, as they had gone over into room 1 on the first west for safety. The explosion, however, covered the entire area of both entries and when found by searching parties several hours

later, Galloway was dead, having succumbed either to after damp or powder smoke, possibly both. Houser was unconscious, but on being taken to the surface was revived with much difficulty, otherwise he suffered no serious inconvenience and was at his work again in a few days.

A very dangerous practice, one for that matter which a majority of shot firers are guilty of, is exhibited in this instance, viz., that of lighting a number of shots in succession, frequently causing a dozen or more to explode at the same moment, thus creating a dense body of powder smoke, sometimes at almost white heat. Also the extra heavy concussion of so many shots raising the coal dust in suspension and should the flame of a blown out shot enter the atmosphere in this condition an explosion of greater or less violence is sure to follow.

On January 12th, Fred Willis, American, aged 18 years, single, was fatally injured by being run over by a loaded mine car, in the Victory Mine, Greene County. At the time of the accident he was coming down a slight grade with a trip of loaded cars at a rapid rate of speed, riding by standing with one foot on the draw bar in the front end of the first car and the other foot on the tail chain. Just as he reached the bottom of the grade, his foot slipped and he fell under the front car and dragged for some distance, crushing him about the head and chest, injuring him so that he died a few days later.

On January 17th, George Hugh, American, aged 46 years, was killed by falling slate in the Linton Semi-Block Mine, Sullivan County. At the time of the accident Hugh and 3 other persons were at work cleaning up a slate fall near the face of a cross entry. A few feet inside the point where they were working was a very dangerous piece of loose slate, which the mine boss had examined when starting the men to work, and gave them orders that no one should go under it until it had been properly secured or taken down, but for some reason decedent, at about 11:30 o'clock, had gone under it and was working when suddenly, without warning, it gave way and a large piece of the slate, measuring 8 feet wide, 10 feet long and 13 inches thick, fell on him, killing him instantly. He leaves as dependents a wife and 5 children. A conformance to the orders given by the mine boss in this instance would have prevented the loss of a life.

On January 25th, Andrew Trueblood, American, loader, aged 25 years, was fatally injured by falling slate in the Wilfred No. 1 Mine, also in Sullivan County. At about 8:00 o'clock a. m. of above date, Trueblood and his buddy were engaged in loading a car of coal and were working within 6 or 8 feet of the face of this room, when a piece of slate 7 feet wide, 8 feet long and 5½ inches thick fell, striking decedent, injuring him so badly that he died 9 hours later at his home. He leaves a wife and 1 child. The accident was investigated by Assistant Inspector Mr. Dodds, who reported plenty of timbers of proper length and cap-pieces on hand, and that the accident could have been prevented had a number of them been set under the slate, which was not done.

FEBRUARY.

Three deaths resulting from mine accidents occurred during this month, the first of which was that of Lew E. Webb, American, aged 52 years, night foreman at the Glendora Mine, Sullivan County. At about 11 o'clock p. m. of the 14th, Webb and 1 other person were engaged thawing out some steam pipes with burning waste. The pipes were located a short distance above the surface, and in order to reach them they were using the east cage. After they had completed the work of thawing out the pipes they came down to the ground, landing on the cage, and the night being very cold they went into the engine room to warm, leaving the cage stationary at the ground landing. After staying in the engine room about 5 minutes decedent started to go down the shaft for the purpose of starting the pump. Both of the shaft gates were standing open and although the pit head was well lighted with electric lights, he in some way made a mistake and stepped into the open or west side of the shaft, falling to the bottom, a distance of 160 feet, killing him instantly. He leaves as dependents a wife and 2 children. An observance on the part of decedent of the statute requiring the mine management to keep shaft gates closed, except when in use, would have prevented this accident.

On February 18th Tillman Shoemaker, American, miner, aged 28 years, was fatally injured by a premature blast in the Oswald Mine, Gibson County. At about 3 o'clock p. m. of above date,

deceased was attempting to charge a shot and his cartridge having stuck fast before reaching the back of the drill hole, it is presumed that he was trying to drill it out with the steel bitt on his tamping bar, and fired the powder by the steel coming in contact with a piece of sulphur, making a spark. This opinion is based on the fact that a fresh cartridge of powder was standing about 4 feet back from where he was working. Also from the fact that the tamping bar was found some 20 feet back from the face of the room, with the bitt pointing toward the drill hole. The bitt was also very warm when examined a few minutes after the accident. When found, decedent was lying about 21 feet back from the drill hole where he was thrown by the shot, and although conscious, his pain was so intense from injuries received that he was unable to give any information as to how the accident occurred, and died 20 hours later without having done so. He leaves a wife and 1 child.

On February 28th, Daniel Shake, American, miner, aged 44 years, was fatally burned by an explosion of blasting powder in the Knox Mine, Knox County. From evidence given at the investigation by deceased himself, he at the time of the accident (12:20 p. m.) was engaged making up cartridges preparatory to charging his shots. He had made and filled with powder 1 cartridge about 2½ feet in length and about 2 inches in diameter, which he leaned up against the coal within a foot or so of his lamp, which was setting on the floor, and while preparing a second cartridge the one leaning against the coal was in some way knocked over on the lamp, igniting the powder, exploding both cartridges and nearly a full keg of powder, from which he was filling the cartridges, burning him both internally and externally, from which injuries he died on March 3d following. He leaves as dependents a wife and 4 children.

MARCH.

Eleven fatal accidents were recorded during this month, the first of which occurred in the Jackson Hill No. 2 Mine, Sullivan County, when on the 6th inst. Jacob Brumitt, American, a driver, aged 26 years, was fatally injured by falling down the hoisting shaft off an ascending cage. At about 3:45 o'clock p. m. deceased having completed his day's work was bringing his mule up the

shaft and when within about 10 feet of the surface landing he in some way fell over and was caught and dragged through between the cage bottom and the buntins, crushing him about the head and chest, permitting him to fall to the bottom of the shaft, a distance of about 90 feet, injuring him so badly that he died 7 days later. He leaves a wife and 2 children. There were no eye witnesses to this accident and it is not known what caused him to fall. It is reported, however, that he stated to some persons a short time after the accident that his mule had reared up while he was holding it, causing him to lose his footing. This statement is, in all probability, true and will explain the cause of his fall.

On March 9th Harlin Lee, American, loader, aged 19 years, single, was killed by a premature blast in the Island Valley No. 2 Mine, Greene County. Decedent and his father were working together as loaders, their duties being to shoot down and load out the coal after it had been under cut with an electric chain machine. Also to timber their working place. On the evening of the above date they had prepared their shots in one of their rooms, which had been under cut 6 feet deep. One of the shots known as the breaking down shot was located in the center of the room, the other two were located one on each rib of the room, the two latter being tamped on fuse, while the center or breaking down shot was tamped on a needle to be fired with a squib. When firing time came the center shot was lighted and both men ran to a place of safety, where they waited until they heard it explode. When they returned to light the 2 shots remaining, the father taking the one on the left and the son the one on the right rib, the father succeeded in lighting his shot, but just as the son was attempting to light the one on the right he discovered that the powder in the fuse was burning, having been lighted from the flame made by the center shot. He called to his father warning him of the danger and they both started to run, the son in the lead, and when he had reached a point some 20 feet from the face of the room, the shot exploded, a piece of the flying coal striking him on the head, killing him instantly. Had common squibs been used to fire these shots, one more victim sacrificed to the practice of using fuse in shot firing would have been spared.

On March 22d occurred in the Oswald Mine, Gibson County, one of the most appalling mine accidents in the history of the

State. Nine lives were sacrificed on that date, 5 of whom were taken from the mine dead and 4 fatally injured, as a result of an explosion of powder smoke, blasting powder and a small amount of coal dust, caused by a windy or blown out shot. This shot had been prepared by a miner named Roscoe Hedrick, and his utter disregard of the statute governing the use of powder and the manner of placing and preparing shots in coal mines, as well as the general methods of mining followed by miners, amounted to nothing more nor less than criminal negligence. An examination of the scene of the accident was made on the day following the explosion by Assistant Inspectors Dodds and Thomas, 2 practical mine superintendents, viz.: Michael King and John Eddy, and myself, which, together with the investigation made by the coroner of Gibson County, and myself, disclosed the following facts: That during the forenoon of the above date, Roscoe Hedrick had prepared a shot in the face of room 10 (his working place) on the fourth south cross entry, on the west side of the mine, by drilling a hole 6 feet 4 inches deep in an almost straight line of face, there being no loose end or chance whatever, other than an offset of probably 18 inches in depth at a point 9½ feet distant, measured at right angles from the drill hole. This hole, probably 4 inches in diameter, was drilled perfectly straight with no lift whatever, and according to testimony given by Hedrick, was charged with 3 feet of powder. It is evident to persons conversant with mining that there could be no other result from a shot so arranged than that which occurred, viz.: a windy or blown out shot. After having prepared the shot Hedrick, wishing to leave the mine for the balance of the day (it then being 11 o'clock a. m.), requested his father, whose working place was on the same entry, to fire it for him at firing time. The father refused to do so and requested him to ask some one else to fire it. He then asked Harry Tagett, whose working place was room 11, adjoining that of Hedrick, to fire it for him, which he agreed to do. Hedrick then left the mine and did not return during the day. The hour as above stated being 11 o'clock a. m. would have given him until 3:30 o'clock p. m. (firing time) 4½ hours in which to have made a shearing, or chance for his shot to do the work intended. It was customary, when firing shots on this entry, to begin at the first rooms and fire toward the face of the entry,

the miners leaving the mine in that direction, traveling against the air, thus avoiding the powder smoke. This same rule was followed on the evening of the accident and some 6 or 8 very heavy shots had been fired one after the other in turn in quick succession. Immediately before Tagett fired that of Hedrick, these shots were all shot off the solid. In addition to the dense body of heated powder smoke made by them, was a certain amount of coal dust brought into suspension by the extra heavy concussion. When Hedrick's shot exploded, the point of least resistance being along the drill hole, it merely seamed the coal from roof to floor, resulting in a windy or blown out shot, the flame of which entering the body of powder smoke and coal dust mentioned, was followed by a smoke explosion which in turn exploded a number of kegs of powder located along the entry in different working places. This, combined with the other two elements, i. e., smoke and dust, added greatly to the intensity of heat, as well as the force of the explosion, which covered the entire area from the face to the mouth of both the third and fourth south entries, also extending down the main entry to within a short distance of the hoisting shaft, tearing out doors and brattices, overturning mine cars, knocking out cross bars, props, etc., wrecking that part of the mine generally. Immediately after the explosion the mine boss, fire boss and others began the work of rescue at great peril to their own lives. No serious results followed, however, and within about 2 hours after the explosion all of the dead bodies and all of the injured, as well as the uninjured, had been rescued. The following is a list of the names of the dead:

Alfred Geiser (German), miner, age 20, single.
Edmun Geiser (German), miner (brother of above), age 22, also single.
William Biggs (American), miner, age 38.
Harry Tagett (English), miner, age 48.
Hudson Weatherly (American), miner, age 30.

Those fatally injured were:
John Dill (American), miner, age 21.
George Dill (American), miner, age 47.
Joseph Ward (American), miner, age 52.
William Jones (English), miner, age 65.

After the investigation had been completed and having secured ample evidence, which in my opinion would justify the prosecution of Hedrick, I placed all of the facts and circumstances relative to the case before the deputy prosecutor of Gibson County, and requested that prosecution be filed against Hedrick in 2 counts, also requesting that he be arrested and placed under bond so that he might not escape punishment, but for some reason the affidavits were not made for several days and when arrested Hedrick was placed under a bond of $150. Later I was informed that Hedrick had plead guilty in the Circuit Court to the charges preferred against him. Up to the present time, however, I have been unable to learn what decision the court has rendered, but am informed that the judge still has the case under advisement, and that Hedrick has been released on his own recognizance, and it is supposed that he had left the place.

APRIL.

Two fatal accidents occurred during this month, the first of which occurred in the yards of the Oak Hill Mine, Vermillion County, when on the 14th inst. James Haga, American, a flat trimmer, was instantly killed by railroad cars at about 1:30 o'clock p. m. Decedent was chalking a car on the scales, and after he had chalked the car and stopped it, he stepped backward out onto the passing or main railroad track just as a coal train was approaching. The brakeman was on the front end of the train and shouted at him, but owing to the noise made by the hoisting and screening machinery, dumping of coal, etc., he could not make him hear. There was a train of 18 cars ahead of the engine and he was struck by the first car, the entire train passing over him before it could be stopped, severing his head and legs from the body.

On April 19th J. W. Spraggins, American, driver, aged 19 years, was fatally injured by being crushed between a loaded mine car and the roof in the Ayrshire No. 8 Mine, Pike County. On the morning of above date, at about 10 o'clock, decedent was coming out of the mine with a trip of 10 loaded cars, riding on the front end of the first car. At the time of the accident he was coming down a steep grade and was fixing his lamp so that it

would give better light, and his attention being so absorbed, he did not notice a low place in the roof which he was approaching and failed to stoop low enough to avoid it. His head struck the roof, crushing him down on the car, injuring his spine, causing total paralysis, from which he died 19 hours later. He leaves as dependents a wife and a younger brother.

MAY.

But 1 fatal accident occurred in this month, viz., that of Anton Lackman, German, a miner, aged 55 years, single, who was killed on May 9th in the Lost Creek Mine, Vigo County. At about 12 o'clock noon decedent was engaged drilling a hole when suddenly, without warning, a large piece of rock 12 feet long, 9 feet wide and 18 inches thick gave way and fell on him, killing him instantly. But one prop had been set under the slate where at least 4 or 5 were needed. Lackman was warned of his danger by a fellow miner, who advised him not to work under the rock, he continuing to do so, however, with the above result.

JUNE.

The records for this month show a total of 8 fatalities occurring in or about the mines, as follows: On June 2d James Phillips, Scotch, miner, aged 30 years, and Jack Ferells, Scotch, also a miner, aged 30 years, were killed by falling slate in the Hocking Mine, Sullivan County. At about 1:30 o'clock p. m. both of the decedents, who worked buddies, were engaged loading a car of coal at the face of a cut off entry. The entry was about 10 feet wide, under cut, 6 feet deep, with an electric chain mining machine, and the empty car which they were loading stood within about 6 feet of the face of the entry. They had loaded out about 2-3 of a shot or undercut, which had uncovered a slip extending directly across the place and up into the roof. They had nearly completed the loading of their car, when suddenly a piece of slate, 9 feet long, 3 feet wide at the bottom (in V shape), 19 inches thick in the center, tapering to a feather edge on the sides, fell out of this slip, striking both men, killing them instantly. Both decedents were married. Phillips leaves a wife and 3 children, and Ferells a wife and 1 child. Both families are in Kilmarnock, Ayrshire, Scotland.

On June 3d, Franz Gerper, Polander, miner, aged 38 years, was killed by a blast in the Lattas Creek Mine, Greene County. At firing time on the evening of above date, Gerper had prepared 2 shots to fire, 1 on each side of his room, both of which were tamped on fuse. When firing time came, he fired 1 of the shots, and his place being filled with powder smoke he called to a neighbor by the name of Steve Kotchis to hold a light for him while he lighted his remaining shot. Kotchis went up into the room and happened to notice that the fuse was burning in the shot, it having been lighted from the flame of the first shot. He shouted to Gerper notifying him of the fact and both men started to run, but when they had reached a point about 11 feet distant from the shot it exploded, pieces of flying coal striking decedent, breaking his neck and killing him instantly. Kotchis was also knocked down and badly bruised, but managed to walk to the bottom of the shaft, where he gave the alarm. Decedent leaves a wife and 5 children, supposed to be in Westphalia, Deutchland. This accident is identical to that occurring in the Island Valley No. 2 Mine. Had common squibs been used in preference to fuse, a life might have been spared.

On June 9th, Paul Phillips, American, loader, aged 19 years, single, was fatally burned by an explosion of fire damp in the Reliance Mine, Sullivan County. From evidence adduced at the investigation of this accident it was learned that prior to the accident William and Paul Phillips had been driving the main east entry. Their duties were to shoot down and load out the coal from this place after it had been under cut with an electric chain mining machine. On the afternoon of the 8th the machine runner in undercutting the place struck a fault from which fire damp was generated after the coal had been shot down by Phillips at firing time (3:30 p. m.). On the morning of the 9th the fire boss, when examining the mine for fire damp, discovered a body of gas extending from the face of the entry back nearly to the first break through, a distance of 40 feet. This he immediately reported to the machine boss, who instructed him to take 2 other persons with him and put up a temporary brattice along the side of the entry to the face, thus directing the air current into the place for the purpose of driving out the gas. The fire boss, however, took 4 men with him instead of 2, viz., his two brothers,

Fred and Henry White, and the two trackmen, J. A. Garwood and Fred Jones, the two Phillips boys also going along so as to be on hand when their working place had been cleared of the fire damp and made safe. The brattice had been constructed to within 10 or 12 feet of the face of the entry and the fire boss was brushing out the gas inside that point with his coat. At this time (7:45 a. m.) the other parties, 6 in number, were sitting in the last break through and some one or more of them had left their lamps, through oversight or carelessness, setting on the entry directly in the path the gas would have to travel when brushed out. The moment the gas came in contact with the open lights, an explosion followed, fatally burning Paul Phillips, also burning the other 6 persons, some of whom were injured more seriously than others; among the latter was William White, the fire boss, whose injuries for a time it was thought would prove fatal. Fred White and Fred Jones were also very seriously burned, the others escaping with slight burns about the face and hands. Phillips died of his injuries on the 12th following.

On June 13th Clinton Harris, American, driver, aged 33 years, was killed by falling slate in the Indiana Block Coal Company's No. 1 Mine at Saline City, Clay County. At about 2:30 o'clock p. m. decedent had gone into a room for the purpose of pulling a car of clay and had sat down near the face of the room and was talking to the two miners who had loaded the car of clay. While so engaged a piece of slate 8 feet long, 4 feet wide and 2 inches thick fell on him, breaking his neck, killing him instantly. He leaves a wife and 1 child.

On Sunday morning, June 25th, Viola Yates, daughter of J. W. Yates, a miner, was killed by falling down the Island No. 1 hoisting shaft, Greene County. Mr. Yates was employed as a loader in the above mine and lived but a short distance from the works, and on the morning of above date had gone over to the shaft to visit, taking his little daughter with him. He was sitting talking to a number of other miners and the child was playing under the tipple and around the shaft with some other children. At about 9:30 o'clock she was missing and search was immediately instituted. Parties descending the shaft found her at the bottom, dead, where she had fallen a distance of 66 feet. There were no eye witnesses to the accident and the general sup-

position is that the child was looking down the shaft, became dizzy and losing her balance, fell in.

On June 28th Richard A. Spurr, American, jerryman, aged 46 years, was killed by falling slate in the Pan American Mine, Parke County. Decedent at the time of the accident was engaged removing some iron rails from an abandoned part of the mine where the pillars had been drawn. At about 11:50 o'clock a. m., while lifting some rails, a large piece of slate 16 feet long, 7 feet wide and 7 inches thick, suddenly gave way, falling on him, killing him instantly. He leaves a wife and 7 children.

On June 30th Matt Karnge, Russian, miner, aged 37 years, was fatally injured by falling slate in the Jackson Hill No. 4 Mine, Sullivan County. Decedent was in his working place as usual on the morning of above date and while engaged in loading a car of coal at about 10 o'clock, working within a few feet of the face of his room, which was well timbered up to that point, a piece of slate six feet long, three feet wide and four inches thick fell on him, inflicting injuries from which he died on July 10th following. He leaves as dependents a wife and four children.

JULY.

Two fatal accidents is also the record for this month. On the 13th inst. Samuel Anderson, Scotch, miner, aged 38 years, was killed by falling slate in the Brazil Block Company's No. 7 Mine, Clay County. At the time of the accident—11:45 a. m. of above date—decedent was engaged mining off a block of coal at the face of his room, when a piece of slate 14 feet long, 11 feet wide and 8 inches thick on the inside, tapering to a thin edge on the outside, fell on him, killing him instantly, also slightly injuring his buddy, John O'Neil, who was loading a car at the time. This slate fall was in the nature of a flat or sand rock roll, and a slip extending up over the rock along the outside edge and around each end had been uncovered, but not noticed by either of the men. They had sounded and examined the rock earlier in the day, and while they knew it was loose, considered it safe to work under, and proceeded to do so with above results. There were ample timbers in the room of proper length to have secured the rock had they been set under it as they should have been. Decedent leaves a wife and two children.

On July 27th George Hillagas, American, miner, aged 23 years, was fatally burned by an explosion of blasting powder in the Island No. 4 Mine, Sullivan County. At the time he received his injury, decedent was and has been for some time employed driving the fourth southwest entry in the above mine and on the evening of the 27th had arranged to fire two shots, one a snubber and the other a back or butt shot. When firing time (3:30 o'clock p. m.) came he tamped up his snubber shot and after lighting it ran back to the first break through, a distance of 27 feet, and while waiting for it to explode was standing about the center of the break through and directly over a full cartridge of powder, 40 inches in length and 2 inches in diameter. There was also an open keg containing about 16 pounds of powder setting beside the cartridge. When the snubber shot exploded, either the flame from the shot traveled back to where he was standing or the extra heavy concussion from the shot jarred a spark from his lamp, falling into the powder, exploding it. Hillagas was unable to furnish us any information on the matter whatsoever, but owing to the fact that the distance from the shot to the break through was but 27 feet and the shot being very heavily charged, I believe the former theory correct—i. e., that the powder was exploded by the flame from the snubber shot. His burns were supposed to be only external and thought not fatal at first, yet he died as a result of his injuries August 9th following. He leaves a wife and two children.

AUGUST.

Seven fatalities is the record for this month, the first of which occurred on the 2d inst., in the Lawton Mine, Vigo County, at which time Earl Martin, American, a trapper, aged 16 years, met his death resulting from being hurled against a mine door by an extra heavy rush of air. There was no eyewitness to the accident, but from evidence brought forward at the investigation held by Assistant Inspector Thomas and the Coroner of Vigo County, together with an examination of the scene of accident made by Mr. Thomas, it was learned that decedent was trapping a door within a short distance of a portion of the mine in which a number of rooms had been worked out and the pillars drawn. At about 1:20 o'clock p. m. of the above date an extra heavy fall of

roof occurred in two of these rooms, the fall or cave having an area of 80 by 100 feet, or 8,000 square feet, and falling a distance of six feet, the height of the coal seam, caused a rush of air equal to a tornado. A driver with a loaded car had just passed through door which decedent was tending, and the supposition is that he was in the act of closing the door when the cave occurred and the rush of air came, which hurled him against the door, crushing his head and breaking his neck, killing him instantly.

On August 3d Peter Francone, Italian, miner, aged 25 years, single, was killed by falling slate in the Glen No. 1 Mine, Clay County. At about 10 o'clock a. m. of above date decedent was assisting Dominic Maretta, a day man, to roll a heavy piece of slate off the roadway, which the latter had pulled down when a second fall came and a piece of slate 4 feet long, 4 feet wide and 6 inches thick fell on him, killing him instantly. Maretta had examined the slate which fell on decedent a few minutes prior to the accident, and decided it was safe to work under, yet his examination could not have been very rigid, as the accident occurred immediately after he made it.

August 7th Ed Evans, American, driver, aged 18 years, was fatally injured by being caught and crushed under a loaded mine car in the Dering No. 8 Mine, Vermillion County. At about 9:00 o'clock a. m. on this date decedent was coming out of the mine with a trip of loaded cars, riding by standing with one foot on the drawbar of the first car and the other on the tail chain. At the time of the accident he was passing through a cut-off and down a short grade, on which was located a canvas door. There were no spraggs in the cars, although there should have been, and the cars were running at rather a high rate of speed. When the mule reached the door for some reason it checked its speed, allowing the cars to run up against it, causing decedent to lose his footing and fall under the front end of the first car, crushing and injuring him so that he died at 5 o'clock p. m. of the same date.

August 8th Victor Bombasorow, Italian, loader, aged 56 years, single, was fatally injured by falling slate in the Big Muddy Mine, Knox County. From evidence adduced at the investigation of the accident, it was learned that some days prior to the accident decedent had fired three shots in his room, which had been undercut with an electric mining machine. Two of the shots were

placed one on each rib and the third one in the center of the room. The latter was known as the breaking-down shot, and was drilled up into the roof some three inches. This shot when fired loosened a piece of slate 7 feet long, 6 feet wide and from 3 to 4 inches thick. At about 10:30 o'clock a. m. of above date deceased was loading a car of coal, working directly under this loose slate when suddenly, without warning, it gave way, falling on him, crushing him and inflicting injuries from which he died at 2:30 o'clock p. m. of the same date.

On August 9th Archie McClelland, Scotch, boss timber man, aged 45 years, was killed almost instantly by falling slate at a double parting in the Glendora Mine, Sullivan County. There was no one immediately present at the time of the accident and little was learned as to the cause other than decedent had charge of the timbering and caring for loose slate on that side of the mine in which the accident occurred and that he knew the slate was loose, having a few minutes prior to his death warned a driver not to pass under it, as it was dangerous. The presumption is that he was either trying to take the slate down or was making arrangements to timber it. When found he was lying under a piece of slate 8 feet long, 5 feet wide and 4 inches thick, and lived about twenty minutes after it had been taken off him. He leaves as dependents two children.

August 21st, at about 8:00 a. m., Ross Williams, American, driver, aged 28 years, was instantly killed in the Cloverland No. 2 hoisting shaft, Clay County. Little could be learned as to the exact cause of this accident except the fact that the mine being idle, the drivers and mules were being sent out of the mine. When it came his turn Williams, with his mule, got on the cage and gave the word to bell it away, the hoisting signal was given and after the cage had ascended the shaft some distance an unusual noise was heard and the engineer was signaled to stop. As soon as the cage was stopped the mine boss called up the shaft to Williams, but got no reply. A miner by the name of Cliff Jackson then climbed up the shaft a distance of 53 feet to where the cage was and found decedent lying on his back on the floor of the cage, his head hanging over and between the cage bottom and a buntin, life extinct. The presumption is that he in some way lost his balance and fell, or was probably thrown against the buntins

by the mule. He leaves a wife and three children. Charges of fast driving and incompetency were preferred by some members of the local union against the hoisting engineer, Fred Shefferman. These charges were investigated by the State President of the miners' organization and myself, at which investigation the charges were proven false and the engineer exonerated from any blame whatever.

August 25th John Duning, American, miner, age unknown, w killed by a shot blowing through a pillar in the Shirley Hill No. 1 Mine, Sullivan County. From evidence brought forward at the investigation of this accident, together with my inspection of the premises, it was learned that the course of room one on the third southwest entry, which was being driven parallel to the main entry, had in some way been turned off its proper course and that the barrier pillar between the two places reduced to about eight feet two inches in thickness. This room was undercut six feet deep with an electric chain mining machine on the day of the accident and a hole drilled five and one-half feet deep on the rib next to the main entry. This shot was charged with 18 inches (possibly two pounds) of powder, and when fired blew through the pillar, throwing out probably one-half a ton of coal, expending its entire force on that side of the pillar. The main entry was the traveling road into and out of the mine for all persons working inside that point. Dunning, whose working place was on the third northwest entry, having completed his day's work, was on his way to the shaft bottom and had reached a point directly opposite that where the shot came through the pillar just as it exploded, receiving the full force of the blast, pieces of flying coal striking him, crushing his skull and mangling him otherwise, killing him instantly. He leaves a wife and five children. Considerable negligence on the part of the mine boss is shown in this accident, as he testified on the witness stand that he thought the pillar was 19 feet thick, but that the only examination made by him to determine that fact was listening to the machine retreat after it had made an undercut. Considering the fact that all of the persons working inside the point where the accident occurred must pass directly by that point, also the additional fact that the men who were driving the room were not English-speaking people, unused to the custom and methods of this country, should

have caused him to take every precaution possible to prevent an accident such as occurred.

OCTOBER.

Three deaths due to mine accidents occurred during this month, the first of which was that of William Mattingly, American, miner, aged 62 years, who was killed instantly on the 16th inst. by falling slate in the Montgomery No. 3 Mine, Daviess County. No one witnessed this accident, and little was learned at the investigation other than the fact that Mattingly had been driving an entry in which the roof was very bad. He had been warned repeatedly to be careful of it by the mine boss, who at one time seriously contemplated stopping the place on account of having so much falling slate to handle, but at the insistence of Mattingly decided to drive it a short distance farther in hopes that the roof would get better. Decedent when discovered by the driver at about 10 o'clock a. m., was lying under a large piece of rock which would wigh probably two tons, and life had been extinct for some time. He leaves a wife and three children.

October 23d Edward Boger, German, driver, aged 30 years, was killed by falling slate at the Big Muddy Mine, Knox County. At the time he met his death (9:00 o'clock a. m.), decedent was going into a room with his mule for the purpose of pulling a car of coal, and when within about 35 feet of the face of the room, while passing under a fault or slip in the roof, a large piece of slate, V-shaped and of slip formation, 7 feet in length, 5 feet wide and 12 inches thick in the center, suddenly, without warning, gave way, falling on him, killing him almost instantly. He leaves a wife, but no children.

On October 24th a second fatal accident occurred in Knox County, when Wilson Moore, American, trackman, was killed by a falling boulder (commonly called by miners "nigger head"), in the Lynn mine. At firing time on the afternoon of the day previous to the accident the coal had caught fire from a shot in the face of one of the working places, and on the following day Moore and several other persons were at work trying to extinguish the fire by mining off the coal that was on fire and throwing water on it. At the time he met his death (2:30 o'clock p. m.) decedent, knowing the boulder which caused his death and the slate sur-

rounding to have been loosened very much by the heat of the fire, was at work shoveling out some fallen slate from under it, preparatory to setting up some props. The place was filled with smoke and steam made by throwing water on the fire, which prevented as thorough an examination of the roof as should have been made, and later development proved the boulder and slate much looser than it was supposed to be. Decedent had just commenced shoveling, and while standing directly under the boulder it and the entire mass surrounding it gave way, falling on him, killing him almost instantly. A son and daughter survive him, but no dependents.

NOVEMBER.

Four fatalities were recorded during this month, the first of which was the death of John Stoivanof, a Servian miner, aged 25 years, single, who was killed on the 19th inst. by an ascending cage in the Mecca No. 3, hoisting shaft, Parke County. Decedent had been showing a couple of friends through the mine, the latter never having been in or seen a mine prior to this time, and at about 3:30 o'clock p. m., having completed their visit, they were returning to the surface. When about twenty feet up from the bottom of the shaft, decedent from some cause fell over against the buntins and the cage, which was running very fast, caught and dragged him through a space of about four and one-half inches between the buntins and the cage bottom, killing him instantly and permitting him to fall back to the bottom of the shaft. There were hand bars within easy reaching distance and had decedent taken the precaution of holding to them the accident would in all probability not have happened.

On November 24th John Kiddele, a Polish miner, aged 40 years, was fatally injured by falling slate in the Lawton Mine, Vigo County. At about 12:00 noon decedent was engaged in loading a car of coal, when a piece of draw slate 5 feet long, 2½ feet wide and 3 inches thick fell on him, dislocating his spine, breaking his leg and injuring him otherwise, so that he died two days later. A dependent wife and three children survive him.

On the same date as that on which the above accident occurred Charles Groves, a Russian miner, aged 28 years, single, was killed

have caused him to take every precaution possible to prevent an accident such as occurred.

OCTOBER.

Three deaths due to mine accidents occurred during this month, the first of which was that of William Mattingly, American, miner, aged 62 years, who was killed instantly on the 16th inst. by falling slate in the Montgomery No. 3 Mine, Daviess County. No one witnessed this accident, and little was learned at the investigation other than the fact that Mattingly had been driving an entry in which the roof was very bad. He had been warned repeatedly to be careful of it by the mine boss, who at one time seriously contemplated stopping the place on account of having so much falling slate to handle, but at the insistence of Mattingly decided to drive it a short distance farther in hopes that the roof would get better. Decedent when discovered by the driver at about 10 o'clock a. m., was lying under a large piece of rock which would wigh probably two tons, and life had been extinct for some time. He leaves a wife and three children.

October 23d Edward Boger, German, driver, aged 30 years, was killed by falling slate at the Big Muddy Mine, Knox County. At the time he met his death (9:00 o'clock a. m.), decedent was going into a room with his mule for the purpose of pulling a car of coal, and when within about 35 feet of the face of the room, while passing under a fault or slip in the roof, a large piece of slate, V-shaped and of slip formation, 7 feet in length, 5 feet wide and 12 inches thick in the center, suddenly, without warning, gave way, falling on him, killing him almost instantly. He leaves a wife, but no children.

On October 24th a second fatal accident occurred in Knox County, when Wilson Moore, American, trackman, was killed by a falling boulder (commonly called by miners "nigger head"), in the Lynn mine. At firing time on the afternoon of the day previous to the accident the coal had caught fire from a shot in the face of one of the working places, and on the following day Moore and several other persons were at work trying to extinguish the fire by mining off the coal that was on fire and throwing water on it. At the time he met his death (2:30 o'clock p. m.) decedent, knowing the boulder which caused his death and the slate sur-

rounding to have been loosened very much by the heat of the fire, was at work shoveling out some fallen slate from under it, preparatory to setting up some props. The place was filled with smoke and steam made by throwing water on the fire, which prevented as thorough an examination of the roof as should have been made, and later development proved the boulder and slate much looser than it was supposed to be. Decedent had just commenced shoveling, and while standing directly under the boulder it and the entire mass surrounding it gave way, falling on him, killing him almost instantly. A son and daughter survive him, but no dependents.

NOVEMBER.

Four fatalities were recorded during this month, the first of which was the death of John Stoivanof, a Servian miner, aged 25 years, single, who was killed on the 19th inst. by an ascending cage in the Mecca No. 3, hoisting shaft, Parke County. Decedent had been showing a couple of friends through the mine, the latter never having been in or seen a mine prior to this time, and at about 3:30 o'clock p. m., having completed their visit, they were returning to the surface. When about twenty feet up from the bottom of the shaft, decedent from some cause fell over against the buntins and the cage, which was running very fast, caught and dragged him through a space of about four and one-half inches between the buntins and the cage bottom, killing him instantly and permitting him to fall back to the bottom of the shaft. There were hand bars within easy reaching distance and had decedent taken the precaution of holding to them the accident would in all probability not have happened.

On November 24th John Kiddele, a Polish miner, aged 40 years, was fatally injured by falling slate in the Lawton Mine, Vigo County. At about 12:00 noon decedent was engaged in loading a car of coal, when a piece of draw slate 5 feet long, 2½ feet wide and 3 inches thick fell on him, dislocating his spine, breaking his leg and injuring him otherwise, so that he died two days later. A dependent wife and three children survive him.

On the same date as that on which the above accident occurred Charles Groves, a Russian miner, aged 28 years, single, was killed

by an ascending cage in the Vigo County Coal Company's Ray Mine, Vigo County. Decedent had forgotten his dinner pail and left it on the pit head when going into the mine to work on the morning of above date, and was returning to the surface to get it at about 6:45 a. m. He stepped on the cage and gave the word to bell it away, and when the cage had reached a point about 25 feet from the bottom he in some way fell over against the buntins and was drawn through between them and the cage bottom, crushing his head and chest, killing him instantly. The cage was well provided with handle bars or supports, and had decedent taken the precaution of holding to them his life might have been spared.

November 28th Lorenzo Patritto, an Italian miner, aged 28 years, was killed by an explosion of fire damp and blasting powder combined in the Zellar McClelland Superior No. 2 Mine, Parke County. From evidence adduced at the investigation of the accident it was learned that Patritto's working place was room No. 2, on the third east entry, and that a heavy fall or cave-in occurred in room No. 1 the evening prior to the accident, opening a small pocket of gas, which accumulated at the face of No. 2 room, and when decedent entered his working place at 7:30 a. m. of above date he fired this gas, which in turn exploded a keg of powder and possibly some dynamite. The force of the explosion hurled decedent across the entry and against the opposite pillar, crushing almost every bone in his body, killing him instantly. He leaves a wife and one child.

DECEMBER.

Two fatalities occurred in this month as follows: On the 18th inst. Frank Ashey, an Austrian miner, aged 26 years, single, was killed by falling slate in the Zellar McClelland Coal Company's Superior No. 3 Mine, Parke County. At the time of the accident —8:00 o' clock a. m.—decedent was engaged mining off a loose shot, when a large piece of slate 20 feet long, 4½ feet wide and 2 feet thick fell on him, killing him instantly.

December 22d George Cassey, American, miner, aged 26 years, was instantly killed by a delayed shot in the Sunnyside Mine, Vanderburgh County. At firing time on the evening of above date decedent had prepared two shots to fire, one of which was tamped

on a needle to be fired with a squib and the other on fuse. After lighting the squib he ran to a place of safety, where he waited until he thought the shot should have had time to explode, and thinking the squib had either missed or had gone out, he returned to light the fuse. When within a few feet of the shot which he was trying to fire with the squib it exploded, hurling him about 25 feet or more down the room, killing him instantly. He leaves as dependents a wife and one child.

The following summary table contains the names, age and occupation of persons killed, cause and date of each accident, the name of mine and county in which the accident occurred, the name of the mine owner and the number of persons dependent on those killed.

SUMMARY OF FATAL ACCIDENTS.

Date.	Name.	Age.	Dependents.	Occupation.	Cause.	Mine.	Company.	County.
Jan. 4	John Galloway	26	3	Shot firer	Smoke explosion	Buckeye No. 2	McClelland Coal Co	Vermillion
Jan. 12	Fred Willis	18	0	Driver	Fell under mine car	Victoria	L. T. Dickason Coal Co	Greene
Jan. 17	George Hugh	46	6	Day laborer	Falling slate	Semi-Block	Linton Semi-Block Coal Co.	Sullivan
Jan. 28	Andrew Trueblood	25	2	Loader	Falling slate	Wilfred	Wilfred Coal Co.	Sullivan
Feb. 8	Tilman Shoemaker	28	2	Miner	Premature blast	Oswald	Princeton Coal & Mining Co.	Gibson
Feb. 12	Len E. Webb	52	2	Night foreman	Fell down shaft	Glendoria	W. S. Bogle Coal Co.	Sullivan
Feb. 28	Dan Shake	44	3	Miner	Powder explosion	Knox	Knox Coal Co	Knox
Mar. 6	Jacob Brummitt	26	3	Driver	Fell off ascending cage	Jackson Hill No. 2	Jackson Hill Coal Co	Sullivan
Mar. 10	Alfred Geiser	20	0	Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	Edward Geiser	22	0	Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	William Biggs	38	5	Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	Harry Tagget	48	0	Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	George Dill	47	5	Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	John Dill	21	0	Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	Joseph Ward	52		Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	William Jones	65	3	Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	Hodson Weatherly	30	3	Miner	Misplaced shot	Oswald	Princeton Coal & Mining Co.	Gibson
Mar. 10	Harlin Lee	19	0	Miner	Premature blast	Island Valley Vo. 2	Island Valley Coal Co.	Greene
Apr. 14	James Hagga	...		Flat trimmer	Run over by railroad cars	Maple Valley	Maple Valley Coal Co.	Vermillion
Apr. 19	J. W. Spraggins	19	2	Driver	Crushed between mine car and roof	Ayrshire No. 3	D. Ingle Coal Co.	Pike
May 8	Anton Lackman	55	0	Miner	Falling slate	Lost Creek	Lost Creek Coal Co.	Vigo
June 2	James Phillips	30	4	Miner	Falling slate	Hocking	Southern Indiana Coal Co.	Sullivan
June —	Jack Ferells	30	4	Miner	Falling slate	Hocking	Southern Indiana Coal Co.	Sullivan
June 3	Franz Gerper	38	5	Miner	Delayed shot	Lattas Creek	Lattas Creek Coal Co.	Greene
June 9	Paul Phillips	19	0	Loader	Explosion fire damp	Reliance	Reliance Coal Co.	Sullivan
June 13	Clinton Harris	33	2	Driver	Falling slate	Ind. Block	Ind. Block Coal Co.	Clay
June 25	Viola Yates	6	0	Female	Not an Employe	Island No. 1	Island Coal Co.	Greene
June 28	Richard A. Spur	46	8	Day laborer	Falling slate	Pan American	Plymouth Block Coal Co.	Parke
June 30	Mat Karnge	37	5	Miner	Falling slate	Jackson Hill No. 2	Jackson Hill Coal Co.	Sullivan
July 13	Samuel Anderson	38	3	Miner	Falling slate	Brazil Block No. 7	Brazil Block Coal Co.	Clay
July 27	George Hillegas	23	3	Miner	Powder explosion	Island No. 4	Island Coal Co.	Sullivan
Aug. 2	Earl Martin	16	0	Trapper	Crushed by mine door	Lawton	Coal Bluff Mining Co.	Vigo
Aug. 3	Peter Francone	25	0	Miner	Falling slate	Glen No. 1	Coal Bluff Mining Co.	Clay
Aug. 7	Ed Evans	18	0	Driver	Fell under mine car	Dering No. 8	Dering Coal Co	Vermillion
Aug. 8	Victor Bomborrow	56	0	Loader	Falling slate	Big Muddy	Big Muddy Coal Co.	Knox
Aug. 9	Archie McClelland	49	2	Timberman	Falling slate	Glendoria	W. S. Bogle Coal Co.	Sullivan

Aug. 21	Ross Williams	28		Driver	Ascending cage	Cloverland No. 2	Zellar-McClellan Coal Co.	Clay
Aug. 25	John Dunning		6	Miner	Shot blowing through pillar	Shirley Hill No. 1	Coal Bluff Mining Co.	Sullivan
Oct. 16	Wm. Mattingly	62	4	Miner	Falling slate	Montgomery No. 3	Daviess Coal Co.	Daviess
Oct. 23	Edward Burges	30	1	Driver	Falling slate	Big Muddy	Big Muddy Coal Co.	Knox
Oct. 24	Wilson Moore	58	0	Trackman	Falling slate	Lynn	Lynn Coal Co.	Knox
Nov. 19	John Slovenoff	25	0	Miner	Ascending cage	Mecca No. 3	Mecca Coal Co.	Parke
Nov. 24	John Kiddle	40		Miner	Falling slate	Lawton	Coal Bluff Mining Co.	Vigo
Nov. 24	Charles Groves	28	0	Miner	Ascending cage	Ray	Vigo County Coal Co.	Vigo
Nov. 28	Lorenzo Patritto	28	2	Miner	Powder explosion	Cloverland No. 2	Cloverland Coal Co.	Parke
Dec. 18	Frank Ashey	26	0	Miner	Falling slate	Superior No. 3	Zellar-McClellan Coal Co.	Parke
Dec. 22	George Cassey	26	2	Miner	Delayed shot	Sunnyside	Sunnyside Coal Co.	Vanderburgh

TABLE

Showing Nationality of Persons Killed in or Around the Mines of Indiana During the Year 1905, Also Persons Dependent on Them for Support.

NATIONALITY.	Number Killed.	Dependents.				
		Wives.	Children.	Father.	Mother.	Other Dependents.
American	29	17	53	1	2	4
Irish	1	1	2	......	......	......
English	1	......	......	......	......	......
Scotch	4	4	8	......	......	......
Polish	1	1	3	......	......	......
Russian	1	......	......	......	1	......
Servian	1	......	......	......	1	......
Austrian	1	......	......	......	1	......
Welsh	1	2	7	......	......	......
German	4	......	......	2	3	4
Italian	3	1	1	1	2	......
Total	47	26	74	4	10	8

COMPARATIVE TABLE

Showing Number of Tons of Coal Mined Each Year, the Number of Persons Employed and the Number of Tons per Each Death from January 1, 1879, to January 1, 1906.

Year.	Tons Produced.	Employes.	Deaths.	Tons per Death.
1879	1,196,490	3,459	Not reported.	....
1880	1,550,375	No report.	Not reported.	....
1881	1,771,536	4,567	10	177,153
1882	1,900,000	No report.	Not reported.	....
1883	2,560,000	5,403	11	232,227
1884	2,260,000	5,716	9	228,888
1885	2,375,000	6,502	7	239,285
1886	3,000,000	6,406	7	228,571
1887	3,217,711	No report.	Not reported.	....
1888	3,140,979	6,685	17	184,763
1889	No report.	....	....	....
1890	3,791,211	6,550	5	758,242
1891	3,819,600	6,975	5	763,900
1892	4,408,471	7,600	19	232,024
1893	4,358,897	7,431	22	193,586
1894	No report.	....	....	....
1895	4,202,084	7,885	23	182,699
1896	4,068,124	7,112	28	170,290
1897	4,088,100	7,934	16	262,630
1898	5,146,920	No report.	22	233,950
1899	5,864,975	7,366	15	390,997
1900	6,283,063	8,858	18	349,059
1901	7,019,203	12,096	24	292,466
1902	8,763,197	13,139	24	365,133
1903	9,992,563	15,128	55	181,683
1904	9,872,404	17,838	34	290,364
1905	10,995,972	17,856	47	233,956

SERIOUS ACCIDENTS.

Of the one hundred and one serious accidents occurring during the year, little can be said other than the fact that they are due to the ordinary risks or dangers incident to mining. The above number includes those who have received broken bones, internal injuries, cuts, bruises, or such other injuries as we think require special mention.

A majority of such accidents have been investigated by this office, and we exhibit by counties in the following table the names and occupations of persons injured, the cause and date of accident, extent of injury, the name of mine and county in which the accident occurred and the name of company owning the mine.

TABLE OF SERIOUS ACCIDENTS.

JANUARY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	County.
Jan. 3	Wm. Jones	Miner	Face, hands, body burned	Blow out shot	Lucia	Mecca Coal Co	Parke.
Jan. 3	Mike King	Miner	Face, hands, body burned	Blow out shot	Lucia	Mecca Coal Co	Parke.
Jan. 3	James Haney	Miner	Face, hands, body burned	Blow out shot	Lucia	Mecca Coal Co	Parke.
Jan. 3	George Baty	Miner	Face and body burned	Blow out shot	Lucia	Mecca Coal Co	Parke.
Jan. 23	Robert Hooper	Trip rider	Foot crushed	Mine car	Black Creek	Black Creek Coal Co	Greene.
Jan. 31	Barney Bemach	Miner	Overcome by smoke	Back on shot	Gifford No. 1	Collins Coal Co	Clay.

FEBRUARY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	County.
Feb. 11	James M. Keith	Driver	Arm broken	Descending cage	Shirley Hill	Coal Bluff Mining Co.	Sullivan.
Feb. 17	George Lang	Pumper	Hand crushed	Pump piston	Jackson Hill No. 2	Jackson Hill Coal Co.	Sullivan.
Feb. 23	Harlan Kays	Miner	Shoulder injured	Falling slate	Ayrshire	D. Ingle Coal Co	Pike.
Feb. 26	Ed Murry	Engineer	Back injured	Fell off boiler	Klondike	Dering Coal Co.	Vigo.

MARCH.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	County.
Mar. 7	James Gilmore	Day laborer	Back injured	Falling slate	Island Valley No. 5	Island Valley Coal Co.	Greene.
Mar. 11	Andrew Maxwell	Miner	Back injured	Falling slate	Island No. 2	Island Coal Co	Greene.
Mar. 11	Name not given	Driver	Foot broken	Mine car	Ayrshire No. 4	D. Ingle Coal Co	Pike.
Mar. 16	Henry Vanatte	Miner	Back injured	Falling slate	Brasil Block No. 4	Brasil Block Coal Co.	Clay.
Mar. 22	John Neal	Boss driver	Leg broken	Mine car	Shirley Hill	Coal Bluff Mining Co.	Sullivan.
Mar. 25	Gregory Sanderson	Driver	Leg broken	Fell under mine car.	Lucia	Mecca Coal and Mining Co	Parke.

APRIL.

Apr. 6..	Lenard Deliand	Miner	Injured internally	Falling slate	Brazil Block No. 8	Brazil Block Coal Co.	Clay.
Apr. 11..	Marion Patton	Miner	Leg broken	Falling coal	Continental	Continental Clay and Mfg. Co	Clay.
Apr. 24..	Virgil Rife	Miner	Severely burned	Explosion of powder	Maple Valley	Maple Valley Coal Co.	Vermillion.
Apr. 29..	Bert Anderson	Driver	Leg broken	Caught by mine car.	Miami No. 1	Miami Coal Co	Vigo.

MAY.

May 5..	Samuel Antis	Machine runner	Fingers and nose broken.	Delayed shot	Vivian No. 5	Vivian Coal Co	Clay.
May 6..	Henry Lawhead	Trackman	Head injured	Falling slate	Burk	Ohio River Valley Coal Co	Warrick.
May 14..	Joseph Urbank	Miner	Back injured	Falling slate	Wheatland	Washington Wheatland Coal Co	Daviess.
May 16..	Jas. F. Andrews	Miner	Shoulder and hips injured.	Falling coal	Miami No. 1	Miami Coal Co	Vigo.
May —	Joe Grugs	Miner	Leg broken	Mine car.	Broadhurst	Home Coal Co	Vigo.
May —	George Snalenburg	Loader	Skull fractured	Delayed shot	Dering No. 14	Dering Coal Co	Vigo.
May 21..	Albert Welch	Miner	Face and body burned.	Blow out shot	Phœnix No. 4	New Pittsburg Coal Co.	Sullivan.
May 21..	Comodore Irwin	Miner	Face and body burned.	Blow out shot	Phœnix No. 4	New Pittsburg Coal Co.	Sullivan.

JUNE.

June 9..	Joseph Savant.	Miner	Leg broken	Premature shot	Superior No. 2	Zellar-McClellan Coal Co	Clay.
June 9..	William White	Fire boss	Severely burned	Explosion fire damp.	Reliance	Reliance Coal Co	Sullivan.
June 9..	Fred White	Timberman	Severely burned	Explosion fire damp.	Reliance	Reliance Coal Co	Sullivan.
June 9..	Henry White	Timberman	Severely burned	Explosion fire damp.	Reliance	Reliance Coal Co	Sullivan.
June 9..	Fred Jones	Trackman	Severely burned	Explosion fire damp.	Reliance	Reliance Coal Co	Sullivan.
June 9..	J. A. Garwod	Trackman	Severely burned	Explosion fire damp.	Reliance	Reliance Coal Co	Sullivan.
June 9..	William Phillips	Loader	Severely burned	Explosion fire damp.	Reliance	Reliance Coal Co	Sullivan.
June 13..	Fred McCleary	Miner	Back broken	Falling slate	Indiana Block No. 1	Indiana Block Coal Co.	Clay.
June 27..	Harry Morris	Miner	Skull fractured	Falling slate	Rosebud No. 2	Vigo County Coal Co.	Vigo.
June —	Tom Bucher	Driver	Spine injured	Falling slate	Hocking	Indiana Hocking Coal Co	Sullivan.

TABLE OF SERIOUS ACCIDENTS—Continued.

JULY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	County.
July 1	Oscar Blair	Miner	Arm fractured	Falling slate	Lower vein block	Lower Vein Block Coal Co	Clay.
July 6	Thomas Beecher	Driver	Spine fractured	Falling slate	Hocking	Indiana Hocking Coal Co	Sullivan.
July 10	Lincoln James	Miner	Leg fractured	Falling slate	Victoria	L. T. Dickason Coal Co	Greene.
July —	Ransome Moore	Driver	Leg broken	Mine car and prop	Victoria	L. T. Dickason Coal Co.	Greene.
July —	Dock Milton	Machine runner	Leg broken.	Machine and mine car	Midland	Midland Coal Co	Greene.
July 12	John Morris	Miner	Leg broken	Falling slate	Gilmour	Indiana Southern Coal Co	Greene.
July 15	John Small	Loader	Back injured	Falling slate	Lattas Creek	Lattas Creek Coal Co.	Greene.
July 17	Carl McAlister	Driver	Finger cut off	Caught by tail chain.	Hocking	Indiana Hocking Coal Co	Sullivan.
July 24	Charles Pingley	Miner	Back injured	Falling slate	Black Hawk	Black Hawk Coal Co.	Sullivan.
July 25	E. W. Rogers	Miner	Toes cut off	Falling slate	Hocking	Indiana Hocking Co.	Sullivan.

AUGUST.

Aug. 7	William Burns	Miner	Leg broken	Mine car	Lawrence No. 7	Zellar-McClelland Coal Co.	Clay.
Aug. 4	George Goodwin	Miner	Ribs fractured	Falling slate	Gilmour	Indiana Southern Coal Co.	Greene.
Aug. 5	Gip Gott	Miner	Ribs fractured	Falling slate	Black Creek	Black Creek Coal Co.	Greene.
Aug. 7	Daniel Morris	Miner	Foot crushed	Falling slate	Kettle Creek	Kettle Creek Min. Co.	Sullivan.
Aug. 8	Ed Thomas	Miner	Back injured	Falling slate	Dering No. 12	Dering Coal Co.	Sullivan.
Aug. 11	William James	Lumberman	Back injured	Falling slate	Hocking	Indiana Southern Coal Co.	Sullivan.
Aug. 16	James Rose	Miner	Severely burned	Delayed shot	Little Giant	Coal Bluff Mining Co.	Sullivan.
Aug. —	John Southard	Miner	Severely burned	Delayed shot	Little Giant	Coal Bluff Mining Co.	Sullivan.
Aug. 22	William Pentlin	Miner	Foot broken	Falling slate	Gilmour	Indiana Southern Coal Co.	Sullivan.
Aug. —	Fred Hatcher	Driver	Fingers cut off	Mine car	Green Valley	Green Valley Coal Co.	Greene.
Aug. 8	Arthur Gray	Miner	Back injured	Went back on shot	Black Creek	Black Creek Coal Co.	Sullivan.
Aug. 8	Richard Ladson	Mine boss	Fingers cut off	Mining machine	Lattas Creek	Lattas Creek Coal Co.	Greene.
Aug. 8	William Willie	Driver	Leg injured	Kicked by mule	Star City	Con. So. Ind. Coal Co.	Sullivan.
Aug. 8	William Highfield	Driver	Leg injured	Kicked by mule	Ind. Con. No. 29	Ind. Con. So. Coal Co.	Sullivan.

SEPTEMBER.

Sept. 7	Estil Matox	Miner	Face, hands burned	Explosion fire damp	Prospect Hill	Sugar Loaf Mining Co.	Knox.
Sept. 10	John Chenewyth	Miner	Severely burned	Premature shot	Consolidated 34	Con. Indiana Coal Co.	Sullivan.
Sept. 15	Henry Heines	Cager	Foot crushed	Mine car	Forrest	Forrest Park Coal Co.	Vigo.
Sept. 15	Frank Wiloby	Miner	Leg broken	Falling slate	Shirley Hill	Coal Bluff Mining Co.	Sullivan.
Sept. 18	George Myers	Driver	Crushed abdomen	Mine car	Knox	Knox Coal Co.	Knox.
Sept. 21	John Howe	Miner	Severely burned	Explosion fire damp	Hocking	Ind. So. Coal Co.	Sullivan.

OCTOBER.

Oct. 10	Thomas Thompson	Miner	Skull fractured	Falling slate	St. Clair	Southern Ind. Coal Co.	Sullivan.
Oct. 14	John D. Davis	Miner	Hip dislocated	Falling slate	Crawford No. 4	Crawford Coal Co.	Clay.
Oct. 23	Robert Moss	Timberman	Spine injured	Falling slate	Forrest Park	Forrest Park Coal Co.	Vigo.
Oct. 25	Clyde Phillips	Driver	Leg injured	Mine car	Hocking	Ind. So. Coal Co.	Sullivan.
Oct. —	Fay Howey	Driver	Internal injuries	Mine car	Parke No. 10	Parke County Coal Co.	Parke.

TABLE OF SERIOUS ACCIDENTS—Continued.

NOVEMBER.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	County.
Nov. 3	George Thompson	Miner	Arm fractured	Falling slate	Troy	Bergenroth Coal Co.	Perry.
Nov. 14	James Callaway	Miner	Head, face injured	Falling slate	Vandalia No. 3	Vandalia Coal Co.	Greene.
Nov. 16	Elmer Wickham	Driver	Leg fractured	Mine car	Semi-Block	Southern Ind. Coal Co	Sullivan.
Nov. —	William Davidson	Miner	Eye injured	Mine pick	Oak Hill	Oak Hill Coal Co.	Vermillion.
Nov. 19	John Lawton	Timberman	Back injured	Falling slate	Mecca No 3	Mecca Coal & Mining Co.	Parke.
Nov. 22	William Taylor	Mine boss	Skull fractured	Coal falling down shaft	Mammoth	Southern Ind. Coal Co.	Sullivan.
Nov. 22	Robert Miller	Cager	Hand crushed	Mine car	Mammoth	Southern Ind. Coal Co.	Sullivan.
Nov. 23	John W. Osborn	Miner	Skull fractured	Falling slate	Vandalia No. 3	Vandalia Coal Co.	Greene.
Nov. 24	Ed Cramer	Miner	Ankle broken	Falling slate	Superior No. 1	Zellar-McClellan Coal Co.	Parke.
Nov. 24	John Cardwell	Miner	Leg broken	Falling slate	Lawton	Coal Bluff Mining Co.	Vigo.
Nov. 25	Addison Sneeks	Carpenter	Leg broken	Descending cage	Deep Vein	Deep Vein Coal Co.	Vigo.
Nov. 28	John Gott	Miner	Arm broken	Falling slate	Superior No. 1	Zellar-McClellan Coal Co.	Parke.
Nov. 28	John Ragus	Miner	Severely burned	Explosion, blasting powder	Superior No. 2	Zellar-McClellan Coal Co.	Parke.
Nov. 29	John Chambers	Driver	Ribs fractured	Mine car	Island No. 4	Vandalia Coal Co.	Sullivan.

DECEMBER.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	County.
Dec. 2	Albert E. Timons	Miner	Skull fractured	Blown-out shot	Fort Branch	Fort Branch Coal Co.	Gibson.
Dec. 3	Orley Frazier	Night watch	Severely burned	Escaping steam	Gifford No. 1	Collins Coal Co.	Clay.
Dec. 6	Wm. Grey	Driver	Abdomen crushed	Falling slate	Mecca No. 3	Mecca Coal & Mining Co	Parke.
Dec. 6	Peter May	Mine boss	Foot broken	Mine car	Kettle Creek	Kettle Creek Coal Co.	Sullivan.
Dec. 7	D. Morgan	Driver	Arm injured	Kicked by mule	Dering No. 12	Dering Coal Co.	Sullivan.
Dec. 16	John Mills	Driver	Collar broken	Fell under mine car	Knox	Knox Coal Co.	Knox.
Dec. 20	Lewis Roberts	Trapper	Foot crushed	Mine car	Knox	Knox Coal Co.	Knox.
Dec. 21	Fred. Bunch	Driver	Leg injured	Mine car	Hocking	Ind. Southern Coal Co.	Sullivan.
Dec. 21	James Pierce	Loader	Back injured	Falling slate	Mildred	Ind. Southern Coal Co.	Sullivan.
Dec. —	D. C. Squires	Driver	Back injured	Mine car	Island No. 4	Vandalia Coal Co.	Sullivan.
Dec. 22	John Galager	Driver	Face injured	Kicked by mule	Dering No. 12	Dering Coal Co.	Sullivan.
Dec. 22	Thomas Ward	Miner	Internal injury	Delayed shot	Sunnyside	Sunnyside Coal Co.	Vanderburgh.
Dec. 24	Earl Archer	Miner	Head injured	Falling slate	Glenn No. 1	Coal Bluff Mining Co.	Clay.
Dec. 24	Charles Miller	Miner	Finger cut off	Mine car	Superior No. 2	Zellar-McClellan Coal Co.	Parke.

ACCIDENTS TO MINE PROPERTY.

Six notable accidents to mine property, which we deem worthy of mention, have occurred during the past year, and have been investigated by this office. Four of these accidents occurred in the inside workings of the mines and four in the surface plants. We give herewith a brief description of each one that occurred.

BUCKEYE MINE.

On the evening of January 4th a smoke explosion occurred in the Buckeye Mine, Vermillion County, resulting in the death of one of the shot firers and almost a total wreck of the mine. So great was the force of the explosion that both cages were wrecked, one of them being thrown up against the sheave wheel, buntins and guides were torn out, mine doors and brattices blown out, cross-bars and other timbers knocked down and fifteen mine cars totally demolished. I have not learned what the financial loss would be, but considering the time the mine was idle, added to the property destroyed, it will probably amount to several thousand dollars.

HYMERA No. 4 MINE.

At about 3 o'clock p. m. of February 7th, a heavy explosion of fire damp occurred in the Hymera No. 4 Mine, which in effect was very much like that occurring at the Buckeye Mine. Both cages were wrecked and thrown to the surface, buntins and guides torn out, doors and brattices blown out, mine cars demolished and timbers of various kinds knocked down, causing heavy slate falls, etc. Fortunately there was no one in the mine at the time, otherwise the results would have been disastrous. It is presumed that the explosion was due to the coal at one of the working faces having been ignited from a shot fired on the evening previous and that a body of gas had accumulated, coming in contact with it.

MECCA No. 1 MINE.

On the night of March 18th the entire surface plant of the Mecca No. 1 Mine, Parke County, was destroyed by fire. This was probably the most destructive mine accident during the year,

as the mine was well equipped with first-class machinery, all of which was rendered useless by the fire. The financial loss was estimated at about $20,000.

SHELBURN MINE.

On the evening of March 20th, at firing time, the coal at the face of one of the rooms in the Shelburn Mine, Sullivan County, caught fire, igniting from a shot. The mine was idle the following day for the purpose of making repairs and the fire was not discovered until Sunday morning, six days later, when smoke was noticed coming out of the shaft. At that time it was not known whether the fire was in the No. V or lower seam, or in the upper abandoned No. VI seam. The superintendent being absent at the time no investigation was made, but the shaft was covered over with loose planks, the purpose being to exclude the air from the fire. On his return, three days later, Superintendent Thomas uncovered and descended the shaft to No. V for the purpose of locating the fire. He had not proceeded more than seventy-five yards from the shaft bottom, however, when he encountered a body of fire damp in such quantity as precluded his making further investigation and having by this time determined the fact that the fire was in the No. V seam and still burning, he hurried to the surface and recovered the shaft with boards and dirt. He had hardly completed his work when a violent explosion occurred, doing considerable damage at the surface and wrecking the interior of the mine. Fortunately no one was injured, although several had narrow escapes from flying debris. The top of the mine was sealed off air-tight again and left to remain so for about five weeks, the fire being extinguished by this time. The shaft was uncovered, necessary repairs made and operations resumed.

GOLD KNOB MINE.

At about 4 o'clock a. m. June 19th the fan house and fan at the Gold Knob Mine, Clay County, was destroyed by fire, entailing a loss of about $600 and causing the mine to remain idle for several weeks.

LUCIA MINE.

During the night of May 9th water broke into and flooded this mine, which since that time has been abandoned. Numerous other accidents of minor character, such as floods, breaking of ropes, cages, etc., incident to mining, have occurred, but as a rule have entailed such small financial loss and an idleness of such short duration we will make no mention of them.

MINE DIRECTORY.

Names and addresses of persons operating mines in each county, also names of mines:

CLAY COUNTY.

COMPANY.	ADDRESS.	MINE.
Brazil Block Coal Company	Brazil	Brazil Block No. 1.
Brazil Block Coal Company	Brazil	Brazil Block No. 4.
Brazil Block Coal Company	Brazil	Brazil Block No. 7.
Brazil Block Coal Company	Brazil	Brazil Block No. 8.
Continental Clay & Mining Company	Brazil	Continental.
I. S. & R. McIntosh Coal Company	Brazil	Rebstock.
Vandalia Coal Company	Indianapolis	Vandalia No. 50.
Vandalia Coal Company	Indianapolis	Vandalia No. 60.
Vandalia Coal Company	Indianapolis	Vandalia No. 6[illegible].
Vandalia Coal Company	Indianapolis	Vandalia No. 64.
Vandalia Coal Company	Indianapolis	Vandalia No. 65.
Zellar, McClellan & Company	Brazil	Superior No. 4.
Zellar, McClellan & Company	Brazil	Superior No. 7.
Crawford Coal Company	Brazil	Crawford No. 4.
Crawford Coal Company	Brazil	Crawford No. 5.
Crawford Coal Company	Brazil	Crawford No. 6.
Crawford Coal Company	Brazil	Crawford No. 8.
Crawford Coal Company	Brazil	Crawford No. 9.
Star Union Coal Company	Indianapolis	Fortner.
Collins Coal Company	Brazil	Gifford No. 1.
Collins Coal Company	Brazil	Gifford No. 2.
Coal Bluff Mining Company	Terre Haute	Glenn No. 1.
Coal Bluff Mining Company	Terre Haute	Glenn No. 2.
American Clay Manufacturing Company	Brazil	Monarch.
Big Vein Coal Company	Terre Haute	Lewis.
Vivian Coal Company	Chicago	Vivian No. 4.
Vivian Coal Company	Chicago	Vivian No. 5.
Indiana Block Coal Company	Saline	Saline.
Jasonville Coal Company	Jasonville	Gold Knob.
Dan Davis Coal Company	Brazil	World's Fair No. 2.
United Fourth Vein Coal Company	Linton	Island Valley No. 4.
Lancaster Block Coal Company	Clay City	Lancaster Block.
Eureka Block Coal Company	Terre Haute	Eureka No. 5.
McLaughlin & Treager	Carbon	Treager.

DAVIESS COUNTY.

Company.	Address.	Mine.
Stucky & Osborn	Raglesville	Stucky.
Daviess County Coal Company	Montgomery	Montgomery No. 3.
Mutual Mining Company	Cannelburg	Mutual.
Mandabach Bros	Washington	Mandabach.
Winklepleck & Overton	Raglesville	Winklepeck.
Overton Coal Company	Raglesville	Overton.

FOUNTAIN COUNTY.

Rush Coal Company	Cleveland, Ohio	Rush.
Silverwood Coal Company	Silverwood	Silverwood.

GREENE COUNTY.

United Fourth Vein Coal Company	Linton	Black Creek.
United Fourth Vein Coal Company	Linton	Island Valley No. 3.
United Fourth Vein Coal Company	Linton	Glenburn.
United Fourth Vein Coal Company	Linton	Antioch.
United Fourth Vein Coal Company	Linton	North Linton.
Vandalia Coal Company	Indianapolis	Vandalia No. 2.
Vandalia Coal Company	Indianapolis	Vandalia No. 3.
Vandalia Coal Company	Indianapolis	Vandalia No. 4.
Vandalia Coal Company	Indianapolis	Vandalia No. 5.
Vandalia Coal Company	Indianapolis	Vandalia No. 6.
Vandalia Coal Company	Indianapolis	Vandalia No. 8.
Vandalia Coal Company	Indianapolis	Vandalia No. 9.
Vandalia Coal Company	Indianapolis	Vandalia No. 21.
Indiana Southern Coal Company	Chicago, Ill	Gilmour.
Southern Indiana Coal Company	Chicago, Ill	Hoosier No. 1.
Southern Indiana Coal Company	Chicago, Ill	Hoosier No. 2.
Southern Indiana Coal Company	Chicago, Ill	Midland.
Southern Indiana Coal Company	Chicago, Ill	Tower Hill.
Southern Indiana Coal Company	Chicago, Ill	Lattas Creek.
Vulcan Coal Company	Indianapolis	Vulcan.
Summitt Coal Company	Bloomfield	Summitt No. 2.
Victoria Coal Company	Linton	Victoria.
Green Valley Coal Company	Jasonville	Green Valley.
Crouch Coal Company	Jasonville	Fry.
Letsinger Coal Company	Bloomfield	Letsinger.
Central Coal and Mining Company	Indianapolis	North West.
Coal Bluff Mining Company	Terre Haute	Twin No. 4.
Coal Bluff Mining Company	Terre Haute	Twin No. 5.
Pennsylvania and Indiana Coal Company	Linton	Pennsyluania.

GIBSON COUNTY.

Princeton Coal and Mining Company	Princeton	Oswald.
Massey Coal Company	Oakland City	Massey.
Fort Branch Coal Company	Fort Branch	Fort Branch.

KNOX COUNTY.

Bicknell Coal Company	Bicknell	Bicknell.
Knox Coal Company	Bicknell	Knox.
Lynn Coal Company	Bicknell	Lynn.
Sugar Loaf Coal and Mining Company	Vincennes	Prospect Hill.
Vandalia Coal Company	Indianapolis	Vandalia No. 4.
Washington-Wheatland Coal Company	Washington	Wheatland.
Chicago and Big Muddy Coal Company	Bicknell	Pine Knot.

PARKE COUNTY.

Company.	Address.	Mine.
Brazil Block Coal Company	Brazil	Brazil Block No. 9.
Brazil Block Coal Company	Brazil	Brazil Block No. 12.
Mecca Coal and Mining Company	Mecca	Mecca No. 3.
Lincoln Coal and Mining Company	Chicago, Ill.	Lyford No. 1.
Otter Creek Coal Company	Chicago, Ill.	Mary.
Zellar, McClellan & Company	Brazil	Superior No. 1.
Zellar, McClellan & Company	Brazil	Superior No. 2.
Zellar, McClellan & Company	Brazil	Superior No. 3.
Vandalia Coal Company	Indianapolis	Vandalia No. 316.
Vandalia Coal Company	Indianapolis	Vandalia No. 317.
Plymouth Block Coal Company	Terre Haute	Pan American.
Parke County Coal Company	Rosedale	Parke No. 1.
Parke County Coal Company	Rosedale	Parke No. 12.
W. P. Harrison	Rockville	Harrison.
C. B. Harrison	Rockville	Harrison.
Clay County Coal Company	Carbon	Clay County.

PERRY COUNTY.

Bergenroth Bros.	Troy	Troy.

PIKE COUNTY.

Ayrshire Carbon Coal Company	St. Louis, Mo.	Aberdeen.
Ayrshire Carbon Coal Company	St. Louis, Mo.	Carbon.
D. Ingle Coal Company	Oakland City	Ayrshire No. 3.
D. Ingle Coal Company	Oakland City	Ayrshire No. 4.
D. Ingle Coal Company	Oakland City	Ayrshire No. 5.
S. W. Little Coal Company	Evansville	Rogers.
S. W. Little Coal Company	Evansville	Blackburn.
S. W. Little Coal Company	Evansville	Littles.
Patoka Valley Coal Company	Huntingburg	Hartwell.
Muncie Coal and Mining Company	Muncie	Petersburg.
Winslow Gas Coal Company	Winslow	Winslow No. 4.
Winslow Gas Coal Company	Winslow	Winslow No. 5.

SULLIVAN COUNTY.

Indiana Southern Coal Company	Chicago, Ill.	Bunker Hill.
Indiana Southern Coal Company	Chicago, Ill.	Caladonia.
Indiana Southern Coal Company	Chicago, Ill.	Phoenix No. 4.
Indiana Southern Coal Company	Chicago, Ill.	Cummins.
Indiana Southern Coal Company	Chicago, Ill.	Hocking.
Indiana Southern Coal Company	Chicago, Ill.	Citizens.
Sunflower Coal Company	Dugger	Sunflower.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 25.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 26.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 28.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 29.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 30.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 31.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 32.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 33.
Consolidated Indiana Coal Company	Chicago	Consolidated No. 34.
Vandalia Coal Company	Indianapolis	Vandalia No. 10.
Vandalia Coal Company	Indianapolis	Vandalia No. 30.
New Linton Coal Company	Indianapolis	West Linton.
Jackson Hill Coal and Mining Company	Terre Haute	Jackson Hill No. 2.
Jackson Hill Coal and Mining Company	Terre Haute	Jackson Hill No. 4.

SULLIVAN COUNTY—Continued.

COMPANY.	ADDRESS.	MINE.
Keystone Coal Company	Chicago, Ill.	Shelburn.
Sullivan County Coal Company	Dugger	Freeman.
Dering Coal Company	Chicago, Ill.	Dering No. 12.
Dering Coal Company	Chicago, Ill.	Dering No. 13.
Dering Coal Company	Chicago, Ill.	Dering No. 14.
Southern Indiana Coal Company	Chicago, Ill.	Semi-Block.
Southern Indiana Coal Company	Chicago, Ill.	Mammoth Vein.
Shirley Hill Coal Company	Terre Haute	Shirley Hill No. 1.
Coal Bluff Mining Company	Terre Haute	Little Giant.
Coal Bluff Mining Company	Terre Haute	Shirley Hill No. 2.
Superior Coal Company	Terre Haute	Superior.
Kettle Creek Coal Company	Terre Haute	Kettle Creek.
Peabody Coal Company	Chicago, Ill.	Reliance.
Linton Bituminous Coal Company	Linton	Hamilton.
United Fourth Vein Coal Company	Linton	Black Hawk.
Clover Leaf Coal Company	Dugger	Clover Leaf.

VANDERBURGH COUNTY.

Diamond Coal Company	Evansville	Diamond.
Thomas Coal Company	Evansville	First Avenue.
D. Ingle Coal Company	Evansville	Ingleside.
Sunnyside Coal Company	Evansville	Sunnyside.
Evansville Coal and Mining Company	Evansville	Union.
Crescent Coal and Mining Company	Evansville	Unity.

VERMILLION COUNTY.

Dering Coal Company	Chicago, Ill.	Dering No. 5.
Dering Coal Company	Chicago, Ill.	Dering No. 6.
Dering Coal Company	Chicago, Ill.	Dering No. 7.
Dering Coal Company	Chicago, Ill.	Dering No. 8.
Dering Coal Company	Chicago, Ill.	Dering No. 15.
Cayuga Press Brick Company	Cayuga	Crown Hill No. 1.
Crown Hill Coal Company	Clinton	Crown Hill No. 2.
Shirkie Bros.	Clinton	Oak Hill.
Shirkie Bros.	Clinton	Maple Valley No. 1.
Shirkie Bros.	Clinton	Buckeye No. 2.
Keller Coal Company	Clinton	Prince.

VIGO COUNTY.

Charles F. Keeler Coal Co	Chicago, Ill	Atherton.
M. D. West	Cloverland	Chicago No. 6.
Coal Bluff Mining Co	Terre Haute	Diamond.
Coal Bluff Mining Co	Terre Haute	Peerless.
Coal Bluff Mining Co	Terre Haute	Lawton.
J. Ehrlich Coal Co	Seeleyville	Seeleyville.
Grant Coal & Mining Co	Burnett	Grant No. 2.
Dering Coal Co	Chicago, Ill	Dering No. 9.
Dering Coal Co	Chicago, Ill	Dering No. 10.
Vandalia Coal Co	Indianapolis	Vandalia No. 66.
Vandalia Coal Co	Indianapolis	Vandalia No. 67.
Vandalia Coal Co	Indianapolis	Vandalia No. 68.
Vandalia Coal Co	Indianapolis	Vandalia No. 69.
Vandalia Coal Co	Indianapolis	Vandalia No. 80.
Vandalia Coal Co	Indianapolis	Vandalia No. 81.
Vandalia Coal Co	Indianapolis	Vandalia No. 82.
Miami Coal Co	Brazil	Miami No. 1.
Miami Coal Co	Brazil	Miami No 2.
Miami Coal Co	Brazil	Miami No. 3.
Parke County Coal Co	Rosedale	Parke No. 10.
Fauvre Coal Co	Indianapolis	Redbird.
West Terre Haute Coal Co	West Terre Haute	Larimer.
Deep Vein Coal Co	Terre Haute	Deep Vein.
Vigo County Coal Co	Seeleyville	Ray No. 2.
Indiana Southern Coal Co	Chicago, Ill	Forrest.
Domestic Block Coal Co	Kokomo	Domestic Block No. 1.

WARRICK COUNTY.

Company.	Address.	Mine.
Hall & Marsh	Chandler	Air Line.
Big Four Coal Co.	Boonville	Big Four.
J. Woolley Coal Co.	Boonville	Big Vein No. 3.
J. A. Bryan	Evansville	Chandler.
Charles Menden	Evansville	De Forrest.
John Archibald Coal Co.	Evansville	Star No. 1.
T. D. Scales Coal Co.	Boonville	Electric.
Ohio River Coal Co.	Evansville	Burke.
Caladonia Coal Co.	Boonville	Dawson.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

OFFICE OF STATE GAS SUPERVISOR,
MARION, INDIANA, Feb. 5, 1905.

Prof. W. S. Blatchley, State Geologist:

DEAR SIR—I have the honor to submit to you my third annual report as State Natural Gas Supervisor, that for the year 1905. This is the fourteenth annual report from this department. In my last report I brought to your attention a few suggestions that would in a great manner have protected the field. Many of these suggestions, approved by you, have been acted upon by this office, and I am pleased to report a better condition in the gas field from both producers' and consumers' standpoint. In this report I shall dwell upon those things which I consider to be of most importance to those interested in the natural gas industry.

I trust the report will receive your approval and that the same will be found worthy of consideration by those interested in the natural gas field of Indiana.

BRYCE A. KINNEY,
State Natural Gas Supervisor.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

The laws governing the production of natural gas have not been changed during the last year. They remain the same and the duties of the State Natural Gas Supervisor are set out in these enactments.

As stated in my last report of 1904 the gas laws were made to conform to and govern existing conditions. The State Legislature from time to time changed these laws so that the attention of this office could be directed in different channels. My purpose in this report is to dwell upon those things which are necessary to the preservation of gas fields, also the dangers that confront the producers of gas in the Indiana fields.

This office is required to incorporate in this annual report to the State Geologist complete and tabulated statistics of the number of gas wells, with the location and record of geological strata passed through in drilling them, the volume of gas produced, the rock pressure, increase or decrease in rock pressure and volume of flow; the number of miles, capacity and cost of mains laid; the cost of gas as a fuel and number of persons employed in the production of gas. It is impossible for this office to give all of the foregoing information, for the reason that the field has developed to such an extent that it is impossible, for the number of persons employed, to collect the correct information. In each and every instance a sufficient number of wells have been visited to gain correct ideas on these points, but it is impossible for me to give the record of each and every well drilled in this locality. The inspection of pipe lines has ceased to be a necessity today on the part of this office, for the reason that all of the larger gas companies employ men to inspect their lines regularly and gas at this time is of such value as to cause gas producers to husband it very carefully. I make a close inspection of all gas lines running in and through cities where escaping gas is liable to cause explosions resulting in great injury and oftentimes loss of life to persons and their property. Gas companies, however, give rather close at-

tention to the lines entering and running through the cities, for the reason that they do not court actions for damages for injury and damages caused by escaping gas.

As stated in my last report, the most important duties required of this office are to see that the laws of the State in regard to the drilling and plugging of wells and the consumption of gas be enforced. During the last six months it has been necessary for me to employ assistants in order to make sure that operators comply with this law. The main trouble has been in the plugging of wells, since, as the field develops and the territory extends, it is impossible for us to be present at every well when it is plugged. It would be more possible to be present at the plugging of wells if the law was such that it would require operators to give notice of the time and place of plugging such wells. There are operators who have drilled wells that were paying producers, who have spent their money and wish to get out of it as cheaply as possible, and these are the men or operators who are causing the trouble in the Indiana field, as they do not properly plug the wells when they are abandoned. For instance, they will try and pull the pipe and casing from such wells, and this pipe or casing will pull apart half way down the well and it is impossible to get the remaining pipe out unless by means of hydraulic jacks, that are used for that business. In the event that they do not draw all of the pipe they can not comply with the law governing the plugging of wells, for the reason that they can not use the iron balls therein provided, and it would take a deputy in every county where gas and oil is found in Indiana to supervise the plugging of such wells. Owing to the experience of this office in such matters, I think we can with propriety suggest such measures as we think necessary in regard to these matters. Before plugging such wells the office of the Natural Gas Supervisor should be notified and he be present or send a deputy to be there. Unless measures of this kind are adopted the gas industry will be abandoned throughout the State of Indiana where the Trenton rock exists.

In different parts of the State where the law has been rigidly enforced during the last five years the gas pressure increased one-third in the past year, which goes to illustrate what could be done if the law could be enforced. Fresh water in the Trenton rock fields not only affects the gas, but it has ruined parts of the oil

fields in Grant, Madison and Delaware counties. If it were not for the fresh water now in the Delaware County fields they would be getting a large production of oil where they are at present pumping water. Different oil men have consulted me frequently in regard to this matter and asked me to suggest some way by which they could be protected from persons improperly plugging these wells. My hands have been tied so far as to being at every well, as I have no way of knowing when these wells are plugged, and it is utterly impossible after a well has been plugged for me to try and replug it, as the iron ball that is seated at the lower end of the former casing prevents the drill from going deeper in the well. One well that has been improperly plugged can do more damage and let more fresh water into the gas-bearing rock than two wells can pump out. In fact, one well being open in a field with twenty other wells in the immediate vicinity will in five years' time ruin the twenty wells. If a well is reported that has been improperly plugged and I have evidence to the fact that would warrant a conviction, I have no means of remedy for the evil already done. As there has been no appropriation made for that purpose, we may convict a criminal, but we can not repair the damage. We have no opportunity to enforce the law, for the reason that the parties are irresponsible or that the wells were left open years ago. The production of natural gas and oil is still a great industry in the State of Indiana, though those that have no knowledge of the industry think that it will soon be a thing of the past. If properly husbanded, oil, and perhaps gas, will be produced throughout the State for years to come. We think a law could be framed in such a manner that the State would not be put to the expense of plugging these wells, but that the same could be provided for in another manner except in cases where the producer is financially irresponsible, or when he has left the State and we are unable to ascertain his whereabouts.

As stated in my report of 1904, the introduction of fresh water into gas localities is a serious evil that threatens both the gas and the oil industry. The existing laws offer no protection against this evil except from wells that are now abandoned. We have no protection for wells that were abandoned years ago. While the opinion oftentimes prevails that an abandoned well will plug itself, this is a mistaken idea, as wells that were abandoned five years

ago and left open remain open today. Those who have producing properties know this to be a fact, for the reason that in operating their properties they can tell that there was a supply of fresh water which could come from no other source except old wells in the vicinity of their property. I have earnestly sought to remedy this evil as far as possible, but I am forced to use only such power as is given me by the State.

CONDITION OF THE GAS FIELD.

The condition of the gas field at the present time is better than a year ago. There is less complaint from the users of natural gas than there was at that time. This I think has been brought about in a measure by the law which was made in regard to the plugging of these wells. Three years ago in the Noblesville (Hamilton County) field various gas companies had given up the piping of gas, but have recently renewed their efforts in drilling new wells and cleaning out the old ones that had practically been abandoned. They have found a rock pressure of 90 pounds and think seriously of repiping this gas to the towns of Noblesville, Cicero and Atlanta.

The Montpelier field, where the pressure was 40 pounds two years ago, has gradually gained, until it has reached a point of 180 pounds. Where Kerlin Brothers were using pumping stations as a means of transporting their gas, they have taken their pumping station out and the natural rock pressure is sufficient to force the gas through the mains to the consumers without the use of pumps.

The Marion Gas Company has its pipes located in the vicinity of Marion, Indiana, and has experienced a similar result. The Citizens' Gas Company of Gas City has had the same experience. In the two plants above mentioned the pressure and supply has increased fully 30 per cent. as compared with what it was one year ago. There has been less drilling done in the past year for gas in the different gas fields than in any previous year from the time gas was first discovered.

Anderson, Indiana, has the best service this year that it has had for the past five years. They are getting the gas from Perkinsville, a point ten miles west of Anderson. The Hazelwood

Gas Company controls this station. They are very well satisfied with the wells they drilled in the past year. They are running one pumping station, as the rock pressure at different points is not sufficient to force the gas through such a long main, and it was necessary to put in this station in order to give a good pressure at the point of consumption.

The Chicago Gas Company are just completing the drilling of one hundred wells between Greentown and Sycamore, Indiana, in the eastern part of Howard County, and the western part of Grant County for the purpose of supplying Chicago and the towns of Kokomo and Greentown, Indiana, with natural gas. This field was practically abandoned six years ago, as the Chicago company were getting their gas at that time from Fairmount, Indiana, but the Fairmount fields have been affected to such an extent by the use of pumping stations that they had to abandon the territory one year ago, and they have gone back to the old field, known as the Greentown field, to get their gas for the coming year. They have drilled one hundred wells with the average capacity of two hundred thousand cubic feet per well. It is my opinion that they can go back to the old gas territory and get producers for years to come, as they are drilling test wells now in different parts of the State, and as at Converse, are finding very good wells that have renewed activity. At Kokomo, Indiana, several wells have been drilled that are fair producers.

In the Princeton field the pressure has decreased to 90 pounds, as compared with 315 pounds three years ago. This result, however, has been anticipated in this particular field, as will be shown by an examination of the reports of Professor Blatchley, and is due to the fact that the gas is found in a different and much thinner formation than that of the other fields. We do not think that the Princeton field possesses the longevity of those fields developed in the Trenton formation. They have done some drilling for gas about Princeton in the last year, and out of seven wells drilled there have been four failures and three producers.

We have had some trouble about plugging old wells at Petersburg, Indiana, also at Princeton, and this may be a factor to be taken into account in considering the decrease of production in that locality. Out of one thousand gas wells drilled in the State in the last eight months, over seven hundred of them have proven

to be producers, but the output is very small when compared with the wells of 1890.

The outlook for next year is bright, as the fields are dismantling their pumping stations and the rock pressure is steadily increasing and giving the consumers of Indiana a better service than we have had in the last three years. We think this is a good omen, for the reason that we do not believe pumping stations are conducive to the welfare and longevity of a gas field. Where pumping stations are not in use the gas pressure offers a certain amount of resistance to the water, and will protect the gas-bearing rock to quite an extent. The use of the pumping station has a tendency to create a vacuum in the gas-bearing rock and encourages the entrance of the water therein. We think pumps can be used without perceptible damage to force gas through the mains to consumers a considerable distance away, but we do not think they should be used to create a vacuum in the well. While gas companies understand this, they attempt to supply the consumer as long as they can with the drilling of additional wells. They then believe that by establishing pumping stations they can increase the supply of gas. This in a measure is true, but it results in a quick death to the territory on which the pumps have been used. The pumps do not increase the supply, but exhaust the stored supply. It would be much better and perhaps more economical to have a greater number of wells and to discontinue the use of pumps altogether except to give a pressure to the gas after it comes to the service. A number of fields are being opened that have been considered dead for the last five years.

ABANDONED TERRITORY.

During the past year many individual wells have been abandoned. At the time of making our last report it seemed that much of the territory had been abandoned, but the redrilling of this territory has proven that it will still produce quite an amount of gas when operated in the proper manner. It is true that some of the gas companies have discontinued operating, but it is also true that others have extended the field of their operation. The increase of the rock pressure in different localities is thought to be an indication of a revival of much of the territory that was thought

to be worthless, and we feel that if proper attention is paid to the preservation of the field in the way of preventing the passing of fresh water into the gas-bearing rock by means of abandoned wells that the gas field will continue to produce gas much longer than was expected one year ago.

NEW TERRITORY.

In the southeastern part of Jay County, the Allen Oil Company drilled a well that had a rock pressure of three hundred forty pounds and a volume of three and a half million feet. This well was drilled in July, 1905, and sold to the Union City Gas Company.

At the present writing they are piping this gas to Union City, and since July several wells have been drilled in this immediate vicinity that are good producers. This is an extension of the Delaware County field, and perhaps does not come under the head of new territory, but it is the only instance of any marked extension beyond what was known to be the confines of the gas field in 1904.

THE CONSUMPTION OF GAS.

The consumption of natural gas has increased during the past year, and while it is true that a number of gas companies have abandoned portions of their properties, they have done considerable drilling on other portions, and instead of their production decreasing as it did during the year 1903, it has increased to a considerable extent. This is due to the fact that the field is in better condition than it was formerly. While it is true that a number of factories in Marion, Gas City, Anderson, Elwood, Matthews, Fowlerton, Converse and others are using gas, the principal consumption is the use of natural gas for domestic purposes and operating in the oil field. All of the cities that are using gas during the year 1904 have continued the use of same, and from the apparent increase in the gas supply it is safe to say that they will continue for a number of years, as the people long ago appreciated the fact that gas as a fuel for domestic purposes is far superior to any other. While it is true that the consumers do not rely wholly upon gas as a fuel during periods of extreme cold, they prefer its use in connection with other fuel on account of its great convenience.

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WASTE OF GAS.

This subject has been thoroughly gone over in almost every report from this office. Conditions have changed somewhat during the year 1905, especially in regard to gas mains. We have discovered that the condition of the main laid through a certain section of the country depends to some extent upon the character of the earth in which it is imbedded, and while in certain parts the main is in almost perfect condition, other parts of it will be perforated on account of the effect that the earth has upon it. This being true, it is impossible to ascertain the condition of a main by examining only a part of it. It is necessary to cover the whole line to get the exact condition.

We have had more or less trouble in the field in drilling new wells. This usually comes from oil operators who are more anxious to waste the gas in order that they may get a better production of oil, as the pressure of gas interferes with producing oil. The law requires that a well must be closed within forty-eight hours after gas has been struck, and it is a hard matter for this office to know when gas is first struck in all the wells drilled in Indiana. We have secured several convictions on this proposition, but we feel safe in saying that the law is frequently violated in this respect. We think perhaps that the same suggestion which we made in regard to the plugging of wells—i. e., that a notice be given this office of the time and place of such work—would be an appropriate one in the instance of drilling in gas and oil fields.

We have also had some difficulty in regard to the use of flambeau burners.

NEW WELLS.

Since 1904 there has been considerable change in the way of artificial means by which gas has been transported from one place to another. At some points pumping stations have been dismantled. For instance, the Lafayette Gas Company have dismantled their Summitville station in Madison county, also the one at Kempton and other points. The capacity of some of the pumping stations has been increased. For instance, the Hazelwood Gas Company, of Anderson, have put in a pumping station ten miles west of Anderson, near Perkinsville, that supplies the city of Anderson, which is having better service this winter than it

has had for several years previous. The different stations, however, are not creating vacuum on the oil and gas-bearing rock, but are used for the purpose of giving a sufficient pressure at the point of consumption.

Marion is also having better service this year than it has had for three years previous. This is owing to the fact that the Grant and Wabash county fields have been carefully watched and that an extra man has been kept in these fields for the purpose of enforcing a strict observance of the law. They have no pumping stations in those localities, but rely on the rock pressure, which runs from 80 to 100 pounds, and at some points as high as 280 pounds. This pressure was found at a point about eight miles north and east of Marion, in sections 8 and 9, Washington Township. The records of the wells, giving the highest pressure and greatest volume, are as follows:

Henry Bradford, No. 3, section 9, on the Henry Bradford farm, was drilled in August, 1905, by the Ohio Oil Company. It produced one million feet daily for thirty days, and is now producing nine millions per month. The record of this well is as follows:

	Feet.
Drive pipe	430
Casing	480
Trenton rock	937
Total depth	987

On the Eliza Bradford, section 9, Washington Township, Grant County, No. 2—

	Feet.
Drive pipe	430
Casing	485
Trenton rock	942
Total depth	990

Gas was first struck in this well at 973 feet. It produced 1,500,000 cubic feet per day for twenty days and is making 7,000,000 feet per month at the present time.

On the John Stribe farm the Ohio Company drilled No. 2 April, 1905, and it made 3,000,000 cubic feet the first twenty-four hours. This well is in section 8, Wabash Township. Its record is as follows:

	Feet.
Drive pipe	140
Casing	430
To the sand	930
Total depth	970

This gas is sold to the Marion Gas Company and used by the consumers at Marion, Indiana. Another good well was struck in July, 1905, in the southeastern part of Jay County on the Jacob Bausman farm, near Salamonie. This well was drilled by the Allen Oil Company for oil. It has a capacity of 3,500,000 feet.

	Feet.
Drive pipe	60
Casing	370
Trenton rock	987
Total depth	1,027

This was perhaps the largest well struck in Indiana in the year of 1905, and was closed in and afterward sold to the Union City Gas Company, and is to be used by the consumers of Union City as soon as the line can be completed that is now under construction. This has undoubtedly opened up a field. They are drilling across the State line in the State of Ohio and are getting good wells, but the exact area of this part of the field in Indiana has not as yet been discovered, for the reason that they are not at the present time in a position to take care of the gas. The Chicago Gas Company is pumping millions of cubic feet of natural gas to Chicago daily. This gas is being produced near Greentown and Sycamore, Indiana, in Grant and Howard counties.

In all probability more wells are being drilled in this section of the State than in any other. This territory had before practically been abandoned. One year ago a test well was drilled one mile east of Greentown and found to be a good producer, making nearly a million feet per day. At the present time there are twenty strings of tools running in this locality and the work of drilling new wells has been progressing rapidly.

They have drilled three new wells near Loogootee, Martin County. The average record of these wells is as follows:

	Feet.
Drive pipe	100
Casing	450
Total depth	490

This gas is found in the same formation as that of the Princeton gas field. The Loogootee gas plant has been giving excellent service this winter to its consumers, and there are also two glass factories at this point which are being supplied with natural gas for the purpose of operating their factories.

THE PETROLEUM INDUSTRY IN INDIANA IN 1905.

By W. S. Blatchley.

For the first time since 1898, and for the second time in its history, the production of petroleum in Indiana fell in 1905 below what it was in the previous year. This decrease in production was due largely to the decrease in price, which, while not below the profit-making limit of 80 cents per barrel, was so much below that of the two years previous that new developments were retarded. Much less wild-catting was, therefore, done during the year, and the area added to the known productive territory of the State was very limited.

It is the custom of this Department to prepare an extended report on the oil industry of the State, with accompanying map, every third year. Such oil reports were issued as portions of the annual reports for the years 1897, 1900 and 1903. Another will be due in the report for 1906. For that reason but brief mention of the more important developments in 1905 will be given in connection with the statistics for the year.

The Trenton Rock Oil Fields of Indiana for the Year 1905

Grant County.—In this county, which in 1902 and 1903 was the principal seat of operations in the Indiana field, but little extension of territory was added during the year. Van Buren Township still continues to be the center of operations. The southwest quarter of section 29 and the north half of the southeast quarter of section 31, both marked undrilled or gassy on the 1903 map, have developed good wells. A deep pay well was sunk on the Wisehart lease in the northeast quarter of section 2 by the Midway Oil Company. This bore penetrated Trenton limestone 347 feet, but found no oil except in the first pay. There are 15 producing wells on this farm, the record of No. 15, completed in July, 1905, being as follows:

	Feet.
Drive pipe	115
Casing	410
Top of Trenton	980
Total depth	1,064

The well was shot with 220 quarts and produced 90 barrels the first 24 hours.

It is stated that the Hudson Oil Company owns 175 wells about Van Buren, which were drilled at the same time as 175 owned by the same company in the Spencerville and Menden fields of Ohio. The Van Buren wells produce large quantities of salt water, and in October, 1905, were yielding 1,100 inches (2,750 barrels) of oil per week, while the Ohio wells, devoid of salt water, were producing but 300 inches (750 barrels) in the same time. This tends to prove that a limited amount of salt water is a good thing in the oil business.

A well on the John Pilkington lease, southeast quarter of section 15, a mile and a half southeast of Van Buren, is ten years old and has produced 60,000 barrels of oil. It still yields 10 barrels per day, though it was bored only 13 feet into the sand and was never shot.

A bore on the Creviston lease, northwest quarter of section 7, showed as follows:

	Feet.
Drive pipe	132
Casing	410
Top of Trenton	1,015
Total depth	1.052
Initial production (barrels)	45

The wells in Washington Township, north and northeast of Marion, are holding up well, though as yet there has been no production west of the Huntington Pike. Two fair producers drilled in 1905 had the following records:

	White No. 6, S. E. ¼ sec. 2. Feet.	Bragg No. 5, N. W. ¼ sec. 12. Feet.
Drive pipe	320	263
Casing	500	400
Top of Trenton	1.011	1.000
Total depth	1.072	1.062
Initial production (barrels)	75	60

In section 17 a bore on the Bradford lease was drilled for gas, but showed a quantity of oil. It was cleaned out and shot, when

it came in as a gas well with 185 pounds rock pressure and a yield of 1,000,000 cubic feet daily.

On the Evan Pugh lease, close to the Wabash County line, in section 5, Pleasant Township, there are three wells, sunk for gas in 1902, which began yielding oil in 1905, and in October were producing seven barrels each per day.

In Center Township many of the wells in and around the Soldiers' Home fell off in production about 50 per cent. during the summer and fall of 1905. A bore in search of deep pay was put down on the S. Wolf lease, west half of the southeast quarter of section 1. It was sunk 360 feet into Trenton, but developed oil only in the top pay. Another deep pay bore was sunk on the Jesse D. Wright farm, northeast quarter of section 14, this township, in July, the record of which shows:

	Feet.
Drive pipe	200
Casing	390
Top of Trenton	915
First gas	930
First oil	945
First salt water	935
Second oil and gas (showing only)	1,220
Total depth	1,257

The bore was shot with 360 quarts and had an initial production of 23 barrels, all of which was supposed to be from the upper pay. No deep pay wells have been developed in Grant County, though a number of attempts have been made in the last two years.

But little if any new territory has been opened up in Monroe Township since the last map was published. The southern half is still considered gas territory, but will doubtless yield a number of light to fair oil wells in the future.

In Jefferson Township a number of light wells were opened up in old gas territory in the southeast quarter of section 19. Six bores were sunk on the Jones and adjoining leases, which started at about 15 barrels and were yielding about 8 barrels each when 60 days old. An average record showed:

	Feet.
Drive pipe	187
Casing	375
Top of Trenton	933
Total depth	1,035

Quite a quantity of salt water was developed and the wells will, therefore, probably hold up for some time.

The Ohio Oil Company (Standard) was operating but 6 strings of tools in Grant County in the fall of 1905, as against 36 in 1904; the reason given being "the low price of oil," though the magnates at the head of the Standard have the fixing of the price.

Huntington County.—Inside of known productive limits in this county a bore is as sure a venture as one can make anywhere in the United States in the oil business. There was, however, little doing here as elsewhere, in the extension of new territory in 1905.

In Salamonie Township, section 36, near Mt. Zion, was formerly known as salt water territory. The water has now gone down and 25 or more new wells, all good ones, have been drilled. The top of Trenton is here found at just about 1,000 feet, and the borers are sunk 100 feet into that formation. The average well, 18 months old, makes 3½ barrels daily. It is stated that 500 producing wells in this region made an average of 10 tanks, or 2,500 barrels, less per month than in 1904.

In Jefferson Township, sections 7, 8, 17 and 18 are now all productive. This territory was formerly mostly owned by the Huntington Light and Fuel Company, and utilized for gas It was sold to the Wagner Oil Company and opened up for oil in the spring of 1905. This company drilled 6 test wells and, on October 4th, sold them and 1,300 acres of leases to the Beatty-Nichol Oil Company for $15,000 cash.

The Wagner Oil Company still controls 4,000 acres in southwestern Jefferson and southeastern Wayne townships. On this territory there is plenty of gas for operating. But little water is encountered, 2-inch tubing being used in all the wells. Two pay streaks are found, one at about 25 feet, the other at 52 feet in the Trenton. Each pay runs 5 to 20 feet in thickness.

On the John Bond farm of 100 acres, in the west half of section 36, Wayne Township, there are 10 wells, drilled in 1904 and 1905, all of which started at about 100 barrels. One of these was drilled 349 feet into Trenton in search of a deep pay, but without results. The 10 produced 243 barrels the week of August 19th, and 184 the week of October 14th.

Well No. 5, on the Hamilton lease, southwest quarter of section 25, Wayne Township, finished August 14, may except in production be taken as an average for this territory, its record being as follows:

	Feet.
Drive pipe	221
Casing	512
Top of Trenton	1,001
Total depth	1,064
Initial production (barrels)	100

The Wagner Company had on November 1, 1905, 120 producing wells on its leases, and claimed never to have drilled a dry hole, the lightest starting at about 10 barrels. The production of the company in March, 1905, was 7,646 barrels; in June, 7,076 barrels, and in August, 7,235. To this the royalty of 1/8 should be added.

Well No. 6, on the D. K. Pinkerton lease, northeast quarter of section 13, Jefferson Township, had the following record:

	Feet.
Drive pipe	170
Casing	520
Top of Trenton	971
Total depth	1,023½
Initial production (barrels)	143

Many of the old gas wells of the Huntington Light and Fuel Company in Huntington and Grant counties were drilled in only 30 feet. When redrilled to 90 feet and shot they are as productive as a new well. No productive wells of any size have been drilled in Huntington County west of the Marion and Huntington pike.

Wabash County.—In the southwest quarter of section 34, Liberty Township, this county, a well was drilled for gas on the 99 acre tract of J. H. Scott, in the fall of 1903. It showed a little oil and in July, 1905, was drilled 40 feet deeper and shot, when it started at 25 barrels and was making 7½ barrels after 30 days' pumping. The original record was as follows:

	Feet.
Drive pipe	202
Casing	470
Top of Trenton	945
Total depth	965

This well is close to the county line, just south of Lafontaine. Several years before another well, 1½ miles west, started at 45

barrels, but afterwards went off to salt water and was pulled. The Scott well was the only one drilled in Wabash County during the year. Four of those near Rich Valley, in Noble Township, were abandoned.

Blackford County.—But 65 new bores were sunk in this county during the year and no one of them opened up any new territory. Of the 65, 10, or 15.4 per cent., were dry, while the initial production of the others averaged less than 8 barrels each.

Wells County.—The only new territory opened up in this county was near Poneto, in section 6, Nottingham Township, and section 31, Harrison Township, where several light wells were drilled. Many new wells were sunk between the old locations in Nottingham, Chester and Jackson townships, but, for the most part, they had an initial production of 10 to 60 barrels, as against 50 to 200 for the older ones. Probably the best well drilled in the county during the year was No. 44, on the Terhune lease, in section 5, Chester Township, which started at 140 barrels. A bore on the Bryant farm, northwest quarter of section 19, Nottingham Township, was sunk 370 feet into Trenton in search of a deep pay, but without results.

Adams County.—But little new territory was added to the known productive area of this county. Only 94 bores were sunk as against 262 in 1904. Of the 94, 11, or 11.7 per cent., were dry. The productive wells averaged a little less than 10 barrels initial production, as against 13.1 barrels the year before. The northern part of Adams County may, in time, develop some oil, as a new well east of Decatur, near Wren, Van Wert County, Ohio, was drilled in October, which started at 120 barrels. This was several miles north of any previous development in that region.

Jay County.—It was in this county that the greatest extent of new territory was added to the productive limits during the year and its area was nothing to brag of. This territory was mainly east of Bryant in Bear Creek Township. One of the best producers of the year was completed October 16, on the R. Dehaff lease, southeast corner of section 17. It is said to have flowed and pumped 300 barrels the first day and would have done better if sufficient tankage had been available. On October 28th it yielded 185 barrels in 21 hours. The record was as follows:

	Feet.
Drive pipe	88
Casing	240
Top of Trenton	989
Total depth	1,026

This was number 4 on the lease, the other 3 having started at 70 barrels each or better.

In Bear Creek Township the depth to top of Trenton ranges from 1,014 to 1,035 feet, due mainly to the variation in surface level, there being an actual difference of 12 to 15 feet in the exact level of the Trenton in different parts of the township. The majority of the wells drilled in had an initial production of 20 to 70 barrels, though a few ran from 100 to 150 barrels. The following table gives the location of the new territory in Bear Creek Township and its relative rank:

S.W ¼ sect. 4	light
E. ½ sect. 9	fair
S.W. ¼ sect. 10	good
S.W. ¼ sect. 12	fair
W. ½ sect. 13	fair
E. ½ sect. 14	fair
N.E. ¼ sect. 16	light
N.W. ¼ sect. 16	fair
S.E. ¼ sect. 17	good
N.W. of S.W. ¼ sect. 19	light
N.E. ¼ sect. 20	good
S.W. ¼ sect. 21	fair
S.E. ¼ sect. 23	light
S. ½ of N.W. ¼ sect. 24	fair
N. ½ S.W. ¼ sect. 24	fair
N.E. ¼ sect. 26	light
S. ½ sect. 28	fair
N.E. ¼ and S.W. ¼ sect. 32	light
N. ½ sect. 33	fair

In addition to the above, there are 2 large gas wells in the southwest quarter of section 14, 1 in the southeast of the northwest of 22, 1 in the northwest of the northeast of 27, 1 in the northeast of the northwest of 27, and 1 in the northeast of the northwest of 29. Some of these are packed and closed, while gas from 1 or 2 is being used west of Portland in burning lime.

In the south half of Bear Creek Township, the Trenton below 35 feet from the top changes to a brownish, nonproductive limestone. Many of the wells which make only a light showing when first completed, after shooting come in as fair to good producers.

In old abandoned territory northwest of Bryant a number of fair to good wells have been lately completed. One of these which started at 100 barrels is on the Callahan lease, southwest quarter of section 7.

In Wabash Township the west half of section 17 produced 3 or 4 fair wells during the year, while several in the south half of 32 started at 10 to 30 barrels each. Dry holes in the southeast quarter of 9, the northwest quarter of 21, the northeast quarter of 22, the northeast quarter of 27, and the northeast quarter of 28 condemned much undeveloped territory in this township.

In Noble Township 2 light producers are located on the northeast quarter of section 4. Several other bores, in the southeast of section 8 and the southwest of 17, developed quite a volume of gas, the rock pressure running 300 pounds or over. This is utilized by the Citizens' Gas Company of Portland.

In Pike Township there was no extension of territory, though 2 or 3 light producers were drilled in on sections 8 and 9, bringing the production up to about 300 barrels per month.

In Greene Township a bore on the northeast of the southwest of section 19 started at 60 barrels and filled a 250 barrel tank, but the company had no money to sink other bores. The oil was found in second pay sand at a depth of 80 feet in Trenton.

In Penn Township some old wells which had been drilled into Trenton only 30 feet with good results, but which had fallen off in production, were re-drilled to a second pay at 65 feet and started off at 60 to 75 barrels each, and promise to hold up well. Several of these were located on the northeast quarter of section 25 and the east half of section 35.

The deep pay wells, sunk in 1904 about Redkey, have mostly been overcome with salt water. A half dozen or so bores have been sunk in search of deep pay in other parts of Jay County, but all of them were failures. One of these, in the northeast quarter of section 6, Wayne Township, was shot and got a small production from the upper pay. One in the northwest quarter of section 20, Wabash Township, was sunk 500 feet into Trenton. Another, in the northeast quarter of section 20, Penn Township, was sunk 450 feet in. A third, in the northwest quarter of section 10, Jefferson Township, was also sunk 450 feet in and a good gas supply obtained in the upper pay. A fourth was located in the

northwest quarter of section 24, Greene Township, and a fifth in the northeast quarter of section 32, Jackson, both of which penetrated the Trenton 500 feet.

Randolph County.—But little new territory was opened up in this county during the year. Several small producers were finished in Jackson Township, near the Ohio-Indiana State line. Two of these, on the Clough lease, northeast quarter of section 9 and northwest quarter of 10, were sunk 285 feet into Trenton, and started at about 20 barrels each. Three or 4 others were drilled on the southwest quarter of section 3 and the southeast of section 4, about 15 miles southeast of Portland. One of these started at 50 barrels. About 1,200 barrels of tankage was filled and a pipe line put in. Other bores just to the west developed gas only, 1 or 2 showing a rock pressure of 300+ pounds and a volume of 1,250,000 feet.

A small producer was drilled on the Huber lease, 1 mile northeast of Deerfield, and another on the Warner farm, in section 25, north of Saratoga, both in Ward Township.

The most extensive operations in Randolph County were in Stony Creek Township, close to the Delaware line. On a tract of 1,200 acres, leased by the Parker-Marion Oil and Gas Company, part in Perry Township, Delaware County, but mostly in Stony Creek Township, 8 test bores were sunk, all of which were practically dry holes. The company bought the leases, paid rentals for 2 years, spent in all more than $20,000, and got nothing. The record of one of the dry holes on the Thornburg lease, in the southeast corner of section 32, Stony Creek Township, may be taken as the average. It showed:

	Feet.
Drive pipe	64
Casing	320
Top of Trenton	956
Total depth	1,307

Five of the other dry holes were located as follows: One just south of Windsor; 1 in the northwest quarter of section 32, Stony Creek; 1 in the southwest quarter of section 4, in the extreme southeastern corner of the tract; and 1 in the northeast quarter of section 1, Perry Township. One bore on the Swingley lease, in the northwest of 33, Stony Creek Township, started at about 5 barrels per day, the oil being found in the upper pay.

The territory tested was about 2 miles long from east to west and 1¼ miles wide. The bores were sunk 300 to 470 feet into Trenton, and the results show that the territory southeast of Windsor is practically worthless.

Several good bores were drilled in section 21, Stony Creek Township, during the year, 1 on the Deeds lease, in the northwest quarter, starting at 200 barrels. A number of other good ones were drilled within the limits of known productive territory in Monroe Township, north and east of Parker.

Delaware County.—As far as new development was concerned, the bottom may be said to have dropped out of the oil business in and around Muncie in 1905. The great boom of 1904 when, as it was said, every citizen who had 50 cents invested it in oil stock, collapsed in the spring of 1905. In the 1904 directory of the city of Muncie there were listed 49 different oil and gas companies and promoters of oil properties. In October, 1905, but 13 of these were in existence. Three causes may be given for the slump, viz.: (a) The low price of oil; (b) too many small companies with not enough capital behind them to operate successfully; (c) water coming in and the production falling off. The great majority of the Muncie citizens who invested in the oil business lost their money. The men who made money in the Delaware County field were from the East and understood their business. They got hold of large leases, partly developed them and then sold for a good price.

Many of the deep pay wells drilled in the Delaware County field in 1904 were sunk too deep. They were drilled through a second pay in search of a third and got salt water instead of oil. These were too expensive to operate and many of them were drowned out.

On the T. B. McCullough lease, about 4 miles north of Muncie, in the south half of section 24, Hamilton Township, a deep pay well was finished October 22, which started at 180 barrels and was producing 150 or more on October 30th. Several fair to good wells have since been sunk in the same region which heretofore was undeveloped.

On the W. A. Bell farm, southwest quarter section 7 (21 N., 10 E.), a bore 1,376 feet deep was drilled through the Trenton, which was found to be 476 feet in thickness. Just below the

Trenton was a blue shale 20 feet in thickness, and below this a sandstone with an abundance of salt water. In a bore near Losantville the Trenton was found to be 525 feet in thickness.

In Delaware Township a number of fair to good productive wells were completed during the year. An average record in the western part of the township is that of No. 5, on the Chas. Marsh lease, southwest quarter of section 17, finished July 28th:

	Feet.
Drive pipe	40
Casing	348
Top of Trenton	936
Total depth	1,235
Initial production (barrels)	40

The 5 wells on the lease, 3 of which were drilled in 1905, were producing 70 barrels daily in October.

On the William Reed farm, in the southwest corner of section 30, Delaware Township, 3 bores were completed, the record of No. 3 being:

	Feet.
Drive pipe	42
Casing	335
Top of Trenton	925
First pay	1,148
Total depth	1,200
Initial production (barrels)	50

The 3 wells were making 35 barrels in October. A number of scattering wells are located between De Soto and Albany, on the west side of the L. E. & W. Railway, but no rich territory has, as yet, been developed.

On the county farm lease of 240 acres, 27 bores have been sunk, 6 being drilled east of the buildings in 1905. Of these 25 were pumping on October 26th, the combined output being about 200 barrels per day.

The gas supply in the Selma-Parker region is exhausted, and the Republic Iron and Steel Company were furnishing operators with gas from northern Delaware County at 50 cents per 1,000 cubic feet. About 6,000 cubic feet per day are used in each ordinary gas engine.

Two large leases which were very active in 1904 were the Black lease and the Dunkin lease, in the west half of section 14, Liberty Township. These had been, for the most part, drowned out by

October, 1905. The L. Winget lease of 40 acres, near the center of section 14, Liberty Township, which was one of the first opened up in this territory in 1903, was producing 5 tanks a month from 10 wells. A 1-6 royalty yielded the owner $118 in September. The largest royalty he ever received was $1,112 in 20 days. This was just after the third well had been finished. Of the 10 wells, 4 were sunk to deep pay, though 1 was afterward filled and shot in shallow pay. On the Sarah Winget lease of 60 acres, just to the east, 6 wells were producing 67 barrels per day in October.

The property of the Republic Iron & Steel Company, consisting of several thousand acres of leases and 350 producing wells, was estimated at $1,100,000 in June, 1904, and $500,000 in June, 1905. On October 27, 1904, the Lewis lease, just north of Smithfield, operated by the Republic Company, was yielding 600 barrels a day from 21 wells. On October 26, 1906, 23 wells on the same lease were producing 120 barrels a day. Of the 25 wells drilled on this lease, 23 were productive.

Another operator was, in 1904, offered $65,000 for his holding of 146 acres and 7 wells in the Selma field. In September, 1905, he tried to sell for $15,000 and could not get it.

The Senior and Scotland Oil Company sold, on December 12, 1904, to the Ohio Oil Company (Standard) 120 acres of leases and 21 producing wells located in section 13, Liberty Township, for $110,000. The wells were drilled between March and December, 1904, and yielded as follows in that year:

	Barrels.
March	249
April	148
May	1,082
June	6,191
July	7,117
August	8,029
September	10,798
October	12,528
November	10,080
December 1 to 12	4,010
Total	60,232

The production as given does not include the royalty of 1-6. The Ohio Company also purchased the property just north, con-

sisting of 310 acres and 21 wells, for $40,000. One of the managers of the Ohio Oil Company is said to have stated that they would lose $50,000 on the 2 properties. These facts are given to show the magnitude of the slump in the oil business in Delaware County in 1905. Such is the nature of the business, however, that as correspondingly large gains may be made in 1906.

The new developments of the year in the Selma field were mainly about Windsor, southeast of Smithfield. On the Howell lease of 80 acres southwest of southeast of section 28 and southeast of southwest of the same section, Liberty Township, 3 good wells and 1 old gas well were located in March, 1905. The lease was making a tank a day and sold at that date for $27,500. The new owners put down 4 bores on the west side of the lease, all of which were very light producers. In this case the slump in value was due to absence of the article sought.

One of the best leases in eastern Liberty Township is that of J. M. Patterson, in the south half of the northwest quarter of section 13. An average of the wells shows:

	Feet.
Drive pipe	95
Casing	360
Top of Trenton	983
First pay	1,258
Total depth	1,273
Initial output (barrels)	300

The J. W. Odle lease, in the northeast quarter of section 25, Liberty Township, is a large producer, but there is little yield east of this section.

Snowdon Bros. & Evans sold, in September, 1905, to the Norton Oil Company, of Massachusetts, leases between Smithfield and Windsor aggregating 397 acres, with 37 producing wells. The settled production of the property was 300 barrels a day, and the price received was $250,000. The wells were located around the borders of the leases, the central portion of which has not yet been tested. There is room for 40 additional locations without crowding. In the wells drilled the top of Trenton ran from 945 to 969 feet, with the pay uniformly about 280 feet lower. A machine for making gas for fuel purposes from crude oil will soon be installed on this lease. Such a machine costs about $500 and

October, 1905. The L. Winget lease of 40 acres, near the center of section 14, Liberty Township, which was one of the first opened up in this territory in 1903, was producing 5 tanks a month from 10 wells. A 1-6 royalty yielded the owner $118 in September. The largest royalty he ever received was $1,112 in 20 days. This was just after the third well had been finished. Of the 10 wells, 4 were sunk to deep pay, though 1 was afterward filled and shot in shallow pay. On the Sarah Winget lease of 60 acres, just to the east, 6 wells were producing 67 barrels per day in October.

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has a capacity of 100,000 cubic feet per day, the cost running about 10 to 12 cents per 1,000.

In this part of Delaware County the big wells fall down rapidly while some of the fair ones hold up remarkably well. One of the latter, belonging to the Snowdon-Evans Company, made 40 barrels per day at the beginning of the year and 32 at the close.

On the Mary C. Cline lease, east of Smithfield, 4 bores were sunk in 1905, of which the best was No. 1, with the following record:

	Feet.
Drive pipe	76
Casing	325
Top of Trenton	940
Total depth	1,227
Initial output (barrels)	100

No. 4, located 1,200 feet due south of No. 1, was a dry hole with a record as follows:

	Feet.
Drive pipe	92
Casing	335
Top of Trenton	920
Total depth	1,198

In October, 1905, there was not a well operated in the town of Smithfield, though during the boom in June, 1904, there were 40 producing wells in the hamlet. Such is the short life of a town lot proposition in the oil business.

In the Muncie field, in October, 8-inch 28-pound drive pipe was worth 92 cents per foot; 6¼-inch casing, 35 cents per foot. The price paid for drilling was 50 cents per foot down to 50 feet in Trenton and below that point 75 cents per foot. In 1904 the price was $1.00 per foot below 50 feet in Trenton. Each well rigged up to pump in the deep pay area costs about $1,600. This does not include cost of power house, power and tanks. Drillers were receiving $4.00 per day; helpers or tool dressers $3.00, and pumpers $60 per month.

A pumping station was erected by the Indiana Pipe Line Company half a mile northwest of Smithfield in the fall of 1904. To it gravity lines run from most of the surrounding leases, and from it the oil is pumped to Montpelier. A similar station is located near Selma. The following table shows the

Number of Barrels of Oil Piped or Shipped from the Muncie-Selma-Parker Oil Field in 1904 and 1905, by Months.

	1904.	1905.
January	42,835	358,483
February	33,081	282,773
March	40,869	321,050
April	46,504	305,129
May	73,162	320,287
June	115,048	311,030
July	176,624	277,177
August	240,050	255,854
September	311,098	230,970
October	384,380	218,052
November	356,173	210,724
December	382,302	200,103
Totals	2,202,126	3,292,292

While the output for 1905 was 1,090,166 barrels, or almost 50 per cent. greater than in 1904, it will be noted that there were but 3 months in 1905 that the yield was as great as it was in any one of the last 4 months of 1904. It will also be seen that the output gradually decreased each month from May to December, 1905.

Madison County.—No extension of territory of any importance was made in this county during the year. The number of bores sunk was 55, of which 25, or 45.4 per cent., were dry. The 30 productive wells had an average initial output of 15.7 barrels each.

The production of the Alexandria field fell off 63.4 per cent., as is shown by the following table, which gives the

Number of Barrels of Oil Piped from the Alexandria (Ind.) Oil Field in 1904 and 1905, by Months.

	1904.	1905.
January	19,705	4,244
February	19,537	4,455
March	20,745	6,264
April	21,639	7,854
May	23,646	8,892
June	29,207	10,359
July	28,666	9,085
August	28,012	8,155
September	6,834	6,963
October	6,071	5,119
November	7,128	3,806
December	5,446	4,014
Total	216,636	79,210

Miami County.—In this county but 5 bores were drilled during the year, 1 of which was a dry hole. The 4 productive ones had an average initial output of 9 barrels each. The production of the pools at Peru and Rich Valley fell off slightly, as is shown by the following table:

Number of Barrels of Oil Piped from Peru and Rich Valley Oil Fields in 1904 and 1905, by Months.

	1904.	1905.
January	4,554	3,332
February	2,907	2,498
March	3,903	4,648
April	4,550	4,146
May	4,061	5,045
June	5,453	5,400
July	4,988	4,758
August	5,675	4,710
September	5,374	4,023
October	4,478	4,553
November	5,241	3,550
December	3,356	4,089
Total	54,540	50,752

Marion County.—No new wells were drilled in the Broad Ripple field during the year, and the production consequently fell off 23.1 per cent., as shown by the following table:

Number of Barrels of Oil Piped from the Broad Ripple Oil Field in 1904 and 1905, by Months.

	1904.	1905.
January	153	588
February	655	294
March	154	147
April	595	592
May	627	...
June	...	548
July	647	458
August	575	...
September	...	579
October	610	...
November	542	299
December	...	...
Total	4,558	3,505

Hamilton County.—Three wells whose initial output ran from 15 to 25 barrels, were drilled in the Fisher's Station pool in Fall Creek Township, in the southeastern corner of this county. Several small producers had been yielding in this field since 1901. The output by months for 1905 is shown in the following table:

Number of Barrels of Oil Produced in the Fishers Station Oil Field in 1905, by Months.

January	289
February	...
March	543
April	1,051
May	837
June	1,363
July	639
August	1,106
September	1,190
October	692
November	618
December	196
Total	8,525

Statistics of the Indiana Trenton Rock Petroleum Industry for 1905.

As already mentioned, the production of Indiana Trenton Rock petroleum fell off in the year 1905. While the loss was slight, being but 3.4 per cent., it was sufficient to mark a backward step.

The tendency in prices during the first half of the year was downward, and during the latter half slightly upward. The fluctuations were, however, at no time very great, there being but 15 cents difference between the minimum and maximum prices paid. Starting the year at the maximum price of 96 cents, it dropped, on January 5th, to 93 cents, and again on the 11th to 90 cents, which figure it held until February 1st, when it dropped to 88 cents. This price was paid until March 25th, when it began slowly to decline, and on May 27th reached the minimum of 81 cents. This was maintained until September 12th, when it began again to rise, reaching 91 cents on October 28th. On November 11th it

dropped to 89 cents, which price was paid till the close of the year. The average price for the year, taking both time and amount received into consideration, was 84 4-5 cents, as against \$1.07½ in 1904, and \$1.14 3-20 in 1903.

The total production of Trenton Rock oil in Indiana in 1905 was 10,892,438 barrels, which, at the average price of 84 4-5 cents, had a value of \$9,236,788. Compared with 1904, this shows a loss of 388,592 barrels, or 3.4 per cent., as against a gain in 1904 over 1903 of 21.3 per cent. However, on account of the much lower average price, the amount received by the producers was \$2,890,319, or 23.8 per cent. less than in 1904.

The first of the following tables gives a complete record of the monthly production of petroleum from the Trenton limestone fields of Indiana for the 15 years beginning January 1, 1891, and ending December 31, 1905. This does not include the amount used in the field for fuel and other purposes, or that wasted by the burning of tanks or the leaking of pipes, but only that shipped or piped by the companies who purchase the oil from the operators. The second table shows the annual production, the average yearly price and the total value by years for the same period:

I. TOTAL PRODUCTION OF TRENTON LIMESTONE PETROLEUM IN INDIANA FROM 1891 TO 1906, BY MONTHS.

(Barrels.)

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	6,171	15,841	111,824	259,000	300,568	365,582	290,746
February	5,981	18,946	96,025	232,107	230,559	241,743	309,922
March	5,159	24,791	131,549	282,376	310,703	386,586	341,961
April	4,973	26,184	146,493	287,330	352,077	395,032	328,779
May	5,757	31,033	186,939	321,502	397,001	417,963	340,023
June	8,136	40,888	209,816	333,479	403,569	434,167	369,803
July	10,809	49,203	241,666	327,349	431,376	422,968	375,249
August	11,693	56,109	248,353	345,031	420,132	407,238	371,921
September	16,500	66,034	245,615	319,588	409,169	415,675	362,528
October	19,029	95,699	252,568	339,424	393,153	394,283	408,179
November	20,801	129,270	245,607	304,020	373,789	337,331	430,958
December	21,715	144,067	236,038	337,450	361,436	362,164	423,069
Totals	136,634	698,068	2,335,293	3,658,666	4,386,132	4,680,732	4,353,138

MONTH.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.
January	317,014	297,291	353,451	425,140	554,038	651,355	714,594	1,038,324
February	272,780	220,440	302,493	384,735	460,473	568,789	664,058	·04,100
March	325,301	290,257	361,590	432,922	573,412	724,969	797,133	1,037,320
April	310,034	325,774	381,804	447,261	579,711	680,921	804,121	964,242
May	311,208	344,831	426,363	482,118	635,752	751,348	851,071	1,011,859
June	3 0,477	334,282	446,492	481,807	633,452	809,438	940,291	1,011,965
July	314,961	329,086	437,087	506,065	696,911	831,005	998,229	937,960
August	332,777	347,621	466,127	523,106	697,040	838,615	,084,560	916,803
September	326,264	332,283	418,716	519,087	672,611	857,117	,104,771	840,804
October	319,490	326,781	467,521	532,960	725,973	873,160	,139,000	791,881
November	310,644	326,802	406,684	510,788	656,457	778,323	,098,832	763,478
December	300,457	332,266	441,347	479,485	650,131	796,291	,084,270	772,102
Totals	3,751,307	3,807,714	4,912,675	5,725,474	7,535,561	9,161,331	11,281,030	10,892,438

II. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1906, WITH VALUE.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.
Total production (barrels of 42 gal.)	136,634	698,068	2,335,292	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307	3,807,714	4,912,675	5,725,474	7,535,561	9,161,331	11,281,030	10,892,438
Total value at wells of all oils produced, excluding pipeage	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,954,411	$1,871,849	$2,228,276	$3,331,750	$4,740,731	$4,775,045	$6,450,440	$10,457,659	$12,127,107	$9,226,788
Value per bbl	$0 40	$0 37	$0 45	$0 48	$0 64	$0 63	$0 43	$0 59⅜	$0 87½	$0 96½	$0 83⅜	$0 85⅝	$1 14$\frac{3}{10}$	$1 07½	$0 84⅜

From the first of the above tables it will be seen that the largest production of Trenton rock petroleum in Indiana in any one month was in October, 1904, when 1,139,000 barrels were brought to the surface. The total production of Indiana Trenton rock oil for the 15 years reached the enormous sum of 77,346,223 barrels, which sold for $64,121,729, or an average of $4,274,782 per year.

In the third table there is shown the number of wells completed in Indiana by months from June, 1891, to January, 1906:

III. NUMBER OF WELLS COMPLETED IN THE INDIANA TRENTON LIMESTONE OIL FIELDS FROM 1891 TO 1906 BY MONTHS.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1891.........	...	...	.	....	......	...	6	6	15	15	15	8	65
1892.........	11	13	18	13	17	19	17	30	25	52	33	47	295
1893.........	20	30	31	36	45	47	47	55	27	72	56	76	542
1894.........	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895.........	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896.........	76	90	86	136	148	150	113	121	70	58	66	66	1,180
1897.........	41	35	40	47	49	52	60	45	55	69	119	54	686
1898.........	41	23	29	43	38	55	53	80	72	82	92	86	694
1899.........	75	48	68	64	87	99	77	104	106	118	106	105	1,057
1900.........	113	67	98	118	165	163	158	155	135	152	118	108	1,580
1901.........	111	72	81	121	167	171	167	169	184	207	220	132	1,802
1902.........	176	113	169	182	247	297	288	279	323	295	320	243	2,932
1903.........	168	178	233	236	331	408	377	387	337	366	375	290	3,686
1904.........	235	157	234	202	296	393	394	383	378	388	320	344	3,724
1905.........	194	130	149	185	196	157	159	145	130	108	163	166	1,882
Total ...	......	......	....	....	.....	......	......	..	....	.....	.....	.....	22,581

From this table we learn by subtraction that 1,842 fewer bores were sunk for oil in the Trenton rock fields of Indiana in 1905 than in 1904. This was a loss of 49.5 per cent.

From the table it may also be learned that, up to January 1, 1906, 22,581 bores had been drilled in the Trenton rock fields of Indiana for oil alone. On that date there were 16,266 producing wells in the field, as against 15,228 on January 1, 1905, a gain

of 1,038 for the year. By subtraction it will be noted that of the total number of bores sunk for oil in the Trenton rock fields of the State, 6,315 have proven dry, or have been abandoned as nonproductive. The number abandoned in 1905 was 607, or 396 more than in 1904, while the number of dry holes drilled during the year was 237, or 146 less than in 1904. Of the total number of bores sunk in 1905, 12.6 per cent. were dry, as against 10.2 per cent. of those drilled in 1904.

On October 15, 1905, there were approximately 16,030 producing wells in the Trenton rock fields of the State. The production of oil for the entire month of October was 791,881 barrels, or an average of 1.59 barrels per well for each day of the month. The average daily output in October, 1903, was 2.54 barrels for each productive well. This loss was due in part to the greatly decreased number of new bores sunk during the year, but mainly to the rapid falling off of the production in the deep pay wells of the Muncie-Selma-Parker field.

The following table shows the number of producing wells, number of dry holes, total bores and average initial production of wells drilled in each of the Trenton rock oil producing counties of Indiana in 1904 and 1905, and also the abandoned wells by counties for the year 1905:

COUNTIES.	Producing Wells, 1904.	Producing Wells, 1905.	Dry Holes, 1904.	Dry Holes, 1905.	Total Bores, 1904.	Total Bores, 1905.	Percentage of Dry Holes, 1904.	Percentage of Dry Holes, 1905.	Average Initial Production of Productive Wells, 1904.	Average Initial Production of Productive Wells, 1905.	Abandoned Wells, 1905.
Adams	237	83	25	11	262	94	9.5	11.7	13.1	9 5	104
Blackford	201	55	21	10	222	65	9.4	15.4	9.8	7.3	95
Delaware	831	570	121	83	952	653	12.7	12.7	44.4	32.6	16
Grant	977	369	91	34	1,068	403	8.5	8 4	11.2	10.7	139
Hamilton	0	3	0	0	0	3	0	0	0	15.	0
Huntington	324	159	8	2	332	161	2.4	1.2	18.2	19.3	35
Jay	277	171	52	33	329	204	15.8	16.1	17.1	15.8	41
Madison	35	30	15	25	50	55	30.	45.4	10.5	15.7	13
Miami	5	4	3	1	8	5	37.5	20.	6.4	8.7	2
Randolph	86	46	27	34	113	80	23.9	42.5	43.2	36 8	0
Wabash	0	1	1	0	1	1	100.	0	0	6.	11
Wells	368	154	19	4	387	158	4.9	2.5	12.	11.4	151
Totals	3,341	1,645	383	237	3,724	1,882	*10.2	*12.6	*21.6	*20.6	607

* Denotes average.

From the table it will be seen that all the large producing counties fell off greatly in the number of productive wells drilled.

the average loss running about 50 per cent. The average initial production of new wells drilled during the year fell off only 1 barrel, which goes to prove that the loss in total production is not due to the failure of the field but to lack of sufficient new development to offset the loss in output of the old wells.

In Delaware and Randolph counties, where there was a great gain in initial production in 1904, due to the heavy output of the deep pay wells, there was a corresponding loss in 1905, showing that the deep pay is not holding up to what it promised in the beginning. In Delaware County the loss was 11.8 barrels per well, while in Randolph it was 6.4 barrels per well. That the deep pay wells still surpass the shallow pay ones of other portions of the field is shown by the fact that of the 33,887 barrels of new production in the entire field during the year, Delaware County alone furnished 18,608 barrels, or 54.9 per cent. The number of productive bores sunk in this county was 570, or 34.6 per cent. of the entire number put down in the field.

Huntington County again leads all the older producing counties with an average initial output of 19.3 barrels, and with but 2 dry holes out of 161 bores sunk, a record that has never before been equaled in the history of the Indiana field. Wells County ranks next with only 4 dry holes out of 158 bores, or 2.5 per cent. against 1.2 per cent. for Huntington. Grant County dropped to second place in number of bores sunk, while her percentage of dry holes and average initial output differs but little from that for 1904. From a careful study of the table one can learn many other facts regarding the relative importance of each county in the field.

Corniferous Rock Petroleum.

No new territory producing petroleum from corniferous limestone was opened up in Indiana in 1905. That formation is producing only at Terre Haute, near the western margin of the State, and in Jasper County in the northwestern part.

At Terre Haute the Phoenix well has been productive since the summer of 1889. It is located near the center of the city, and for 12 or more years yielded an average of more than 1,000 barrels per month. In the last few years this has gradually lessened and in 1905 the average was 483 barrels per month.

The Phoenix was one of the few wells which continued to produce oil in quantity after the famous strike in May, 1889. The top of the oil bearing stratum at Terre Haute ranges between 1,569 and 1,630 feet. Some 40 bores were sunk in 1889 and 1890 within a radius of 3 miles of the Phoenix well, but only half a dozen or so produced oil in commercial quantities. Several other small producers were sunk about 10 years later, and 1 of these and the Phoenix are the only 2 now producing oil in the territory. Their combined output for 1905 was 7,064 barrels as against 8,303 in 1904. This was sold to local consumers at an average price of $1.10 per barrel, the whole amount received being $7,770.

There is little doubt but that a large quantity of oil occurs in the corniferous rocks beneath the city of Terre Haute and vicinity, else the yield of the Phoenix well could not have been so long continued. The porous area or reservoir containing the oil must, however, be narrow, and this bore probably struck it at just the right point to get the best results. Some people who know little or nothing of the geology of Indiana believe that the Phoenix well struck a crevice, which extends to the main oil field of the State. Such belief is, of course, preposterous, as the corniferous rock which contains the oil at Terre Haute outcrops before the main oil field is reached, and is not pierced by any bore sunk in that field. Moreover, it is a younger and much thinner formation than the Trenton limestone, and for that reason there is little chance of developing an oil output near Terre Haute in any way comparing to that of the main Indiana field.

In the Jasper County field the corniferous or oil bearing limestone is found from 100 to 115 feet below the surface. On account of this shallow depth the output is small in quantity and heavy in quality, being a bluish or very dark green lubricating oil with a viscosity of 1274 at 90° Fahr. and a gravity of 19.4 Beaume. The output of the field for the year fell off about one-half from that in 1904, when it was 9,800 barrels.

Huron Sandstone Petroleum.

Petroleum from this formation is now produced in Indiana only in the vicinity of Princeton, Gibson County, in the southwestern corner of the State. In this field the top of the oil-bearing

stratum, which is a bluish gray, sharp-grained sandstone, is found at an average depth of 890 feet below the surface. The oil is found at about 40 feet below the top of this sand. It is darker and thicker than that found in the Trenton limestone, registering about 31° Beaumé. For a long time the Indiana Pipe Line Company paid 35 cents less per barrel for it than for the Trenton limestone product, but on August 15th, 1904, advanced the price to the same figure.

On January 1, 1905, there were 45 wells producing oil, 8 yielding gas and 13 dry holes in the Princeton field. During that year there were drilled 34 additional bores, but 1 of which was dry. The average initial output of the 33 productive wells was 10.3 barrels. The output of the field by months for the years 1904 and 1905 is shown in the following table:

Number of Barrels of Huron Sandstone Oil Piped or Shipped from the Princeton (Ind.) Field in 1904 and 1905, by Months.

	1904.	1905.
January	1,412	4,043
February	1,399	3,637
March	2,920	5,400
April	1,319	5,262
May	2,047	5,559
June	2,315	4,523
July	2,971	5,569
August	2,991	6,296
September	3,345	6,141
October	3,093	6,865
November	4,554	6,116
December	3,841	5,395
Totals	32,207	64,806

By subtraction we learn that the production of the field was 32,599 barrels, or a little over 100 per cent. greater in 1905 than in the year preceding, which is an excellent record. The total value of the oil produced was $55,413, an average of 85½ cents per barrel.

Adding to the output of the Trenton rock petroleum fields that produced by the corniferous limestone at Terre Haute and in the Jasper County field, and by the Huron sandstone at Princeton, we find the total production and value of petroleum in Indiana in 1904 and 1905 to be as follows:

TOTAL PRODUCTION AND VALUE OF CRUDE PETROLEUM IN INDIANA FOR THE YEARS 1904 AND 1905.

	1904.		1905.	
	Barrels.	Value.	Barrels.	Value.
Trenton Rock Petroleum	11,281,030	$12,127,107	10,892,438	$9,236,788
Corniferous Rock Petroleum	18,103	21,040	12,064	13,270
Huron Rock Petroleum	32,405	28,951	64,806	55,413
Total	11,331,538	$12,177,098	10,969,308	$9,305,473

	Barrels.	Value.
Loss in 1905	362,230	$2,871,625

FAUNA

OF THE

Salem Limestone

OF INDIANA.

E. R. CUMINGS. J. W. BEEDE.
E. B. BRANSON. ESSIE A. SMITH

FAUNA OF THE SALEM LIMESTONE OF INDIANA.

INTRODUCTION.

By E. R. Cumings and J. W. Beede.*

A portion of this fauna has been well known since Hall's description of it appeared in the transactions of the Albany Institute† in 1856. These descriptions were published without illustrations, and were republished with very valuable comments and excellent lithographic illustrations by Whitfield, in 1882, in Bulletin 3, Volume I, of the American Museum. These plates were republished by Hall, with his original descriptions, in the 12th annual report of the Indiana Survey in 1882. Most of the remainder of this remarkable fauna has been brought to light, a species here and another there, and published in the leading geologic periodicals and reports of this country and Europe, in such a manner as to be practically inaccessible to any one in the State wishing to take up its study, and some of the material, especially the Bryozoa, has never been described and figured at all.

It is the object of these papers to assemble, describe and illustrate, as nearly as may be, all the species of this fauna and pass it in such a critical review as the time and means at our disposal will permit.

The fossils treated are limited to those occurring in the State of Indiana and the stratum of limestone known under the various names of "Bedford oölitic limestone," "Indiana oölite," "Warsaw limestone," "Salem limestone," and "Spergen limestone" recently proposed by Mr. E. O. Ulrich without any warrant whatever. The discussion of the nomenclature of this limestone will be taken up later by the writers. The outcrop of this limestone is accurately shown on the map recently issued by the Indiana Survey, and its characters and occurrence have been thoroughly discussed

*The order of these names is without significance.
†Trans. Alb. Inst. IV. 1856.

by Hopkins and Siebenthal in the twenty-first annual report of the Indiana Survey, 1897. This limestone rests upon the Harrodsburg limestone, which is the basal limestone of the Indiana Mississippian, in the northern part of its outcrop and upon a shale in a large portion of its southern outcrop, as at Spergen Hill and Lanesville. At the former locality there is a depositional unconformity, mentioned later. The formation is, in a very broad way, rather lenticular in its occurrence, pinching out in at least 2 places and attaining a thickness of 50 or 60 feet in the vicinity of Bedford. Where typically developed it is oölitic or semioölitic in structure and frequently noticeably cross bedded.

The fossils of this limestone in its typical development are characterized by their stunted form and extreme abundance. Many of these species are found in the rocks above or below and are then of normal size, usually several times as large as their representatives found in the Salem limestone. In exceptional cases, in favorable locations, the species in this horizon reach nearly or quite normal size. Sometimes at the base of this limestone, as at the type locality at Spergen Hill, the very base of the formation is peopled with the fossils typical of the limestone below, but these are quickly replaced by the typical Salem fauna. In some instances the corals, brachiopods, etc., reach normal size in the very top of the formation, as at Bedford and Bloomington, and in such cases the typical fauna has again disappeared to a very large extent, as will be shown later. In these cases the fossils undoubtedly lived in quiet water where the sediment settled upon them rapidly, and the rocks, apparently, never thoroughly consolidated, leaving the fossils in a most excellent state of preservation, in a matrix very soft and easily removed without injury to the most delicate specimens. In this condition great fronds of bryozoa as much as 18 centimeters in diameter have been found and developed, and brachipods with double-barreled, barbuled spines a half inch long are to be obtained.

Fossils are to be found in greater or less abundance most anywhere along the outcrop of the formation, but at certain localities they are extremely abundant. Following is a brief mention of the more celebrated of these localities:

At Lanesville, Harrison County, save at some exposures of this rock where a few fossils are found in the matrix, the fossils are

found in the red clay banks which are the result of the disintegration of the limestones.

Paynters Hill, 3 miles east and 2 miles south of Salem, Washington County, is a low knoll at the forks of the road, the top of which is made up of red clay, derived from the decay of the limestone and the layer of chert which once formed the top of the Salem limestone at this point. This clay teems with fossils silicified upon weathering from the limestone. Corals and echinoderms appear to be more susceptible to silicification under such conditions than pelecypods and gastropods and the like, and as a result the former make up the bulk of the fauna preserved here. The fossils are best secured by shipping large amounts of clay to the laboratory and carefully washing it.

The Spergen Hill cut is located on the C. I & L. R. R. about ¼ of a mile south of Norris Station, Washington County, on the east side of Spergen Hill. The cut exposes practically the full thickness of the limestone. The base of the oölote here is very uneven and undulating, resting in part on the masses of limestone but mostly on shale where the limestone had been carried away and the shale deposited. The very base of the Salem limestone, particularly in the north end of the cut, carries a Harrodsburg limestone fauna intermingled with the Salem limestone fauna, which quickly replaces the former. At or near the top of the stratum is a layer of chert or silicified limestone. The best preserved specimens are to be had by soaking and breaking up the more rotten portions of the limestone into small particles in the laboratory and selecting the fossils after carefully washing the material. At the top of the cut on the east side is a considerable amount of red clay, some of it in situ, resulting from the solution of the limestone, in which there are many species of beautifully silicified fossils, rare in the stone below.

At Bedford, Lawrence County, the best fossils occur in the region of the Dark Hollow quarry, reached on the Bedford and Bloomington branch of the Monon R. R. They occur in the "top bastard" stone of the quarrymen. This is a transitional layer between the quarry stone and the Mitchell limestone above. Large brachiopods, bryozoans, and corals abound.

Plate I.

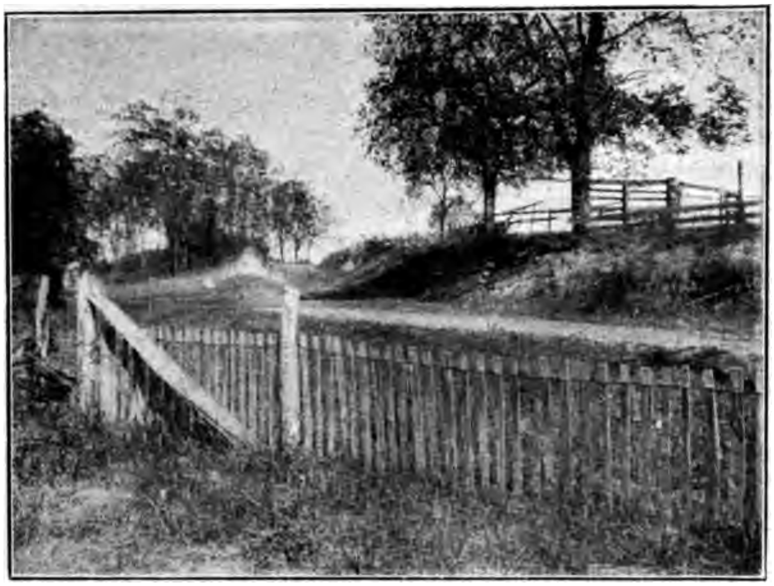


Fig. 1. The locality at Paynters Hill. The white collecting sack in the left of the picture represents the principal locality with the shade of the big tree on the left side of the road.

Fig. 2. The old Cleveland quarry at Harrodsburg. The main part of the quarry is not shown in the picture. The pile of white sand in the foreground is merely a pile of fossils disintegrated off the limestone block above with an admixture of dirt and the calcite cementing material of the stone.

Plate II.

Fig. 1. The cut at Spergen Hill.

Fig. 2. The outcrop of the Salem limestone at Lanesville. About three feet thick at this place.

Plate III.

Fig 1

Fig. 2.

Figs. 1 and 2. Two slightly different views of the west side of the cut at Spergen Hill showing the uneven base of the limestone and the remnants of a limestone lens and the surrounding shale on which the Salem limestone rests.

Plate IV.

Fig. 1.

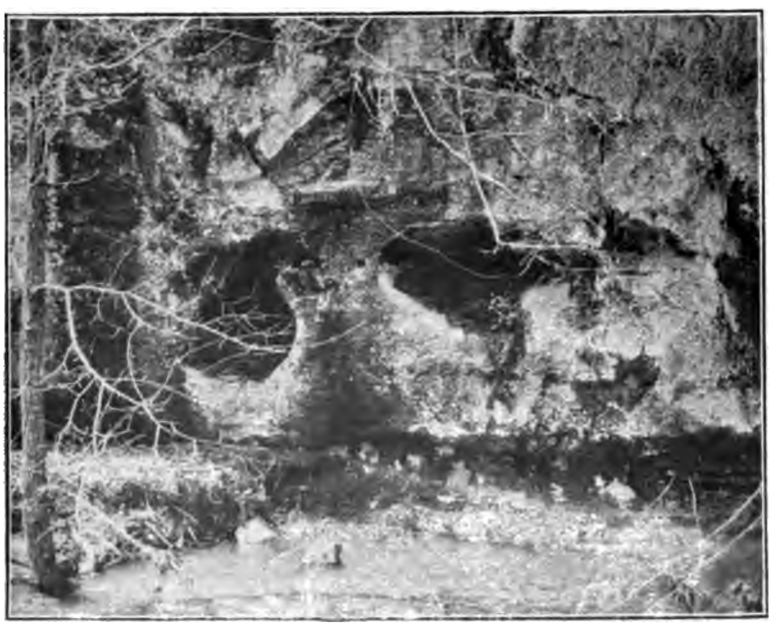


Fig. 2.

Two scenes from the Big Creek Quarries.

. Plate V.

Fig. 1. The east side of the cut showing the scaling off by weathering. These small slabs soaked and hammered up yield the most perfect fossils to be had at Spergen Hill.

Fig. 2. Illustrates the uneven contact of this limestone and the underlying shales and limestones. West side of cut at Spergen Hill.

A little over a mile northwest of Harrodsburg, Monroe County, is the abandoned "Cleveland quarry." At this place the limestone crumbles very rapidly to sand composed almost entirely of organic remains with the crystalline calcite cement of the stone. Large amounts of this sand are formed each year and millions of specimens of the typical fauna, greatly stunted, are to be had each spring.

The collecting locality at Bloomington, Monroe County, lies 3 miles northwest of the city in the abandoned quarries in the "Hunter Valley" district. Here large slabs literally filled with the most delicately preserved specimens have been found, producti and other spinous species, with all the spines intact are to be had.

At Ellettsville, Monroe County, in the Matthews quarry, at a certain horizon near the top is a layer rich in fossils, many of them of normal size; sometimes blocks of large size are found almost entirely composed of shells which break out fairly well when the rock is soaked and hammered up.

The Stinesville, Monroe County, locality is on Big Creek, a mile or more northwest of the station, at the abandoned quarry. The fossils are most abundant on the south side of the creek on the ledge just opposite the site of the old mill. Here many of the fossils, in good state of preservation, are weathered out free in the calcareous earth.

The most of the scanty fauna found at Romona, Owen County, is to be found in the abandoned quarry north of the ravine, just north of the town.

The fauna is best developed at the classic old railroad cut at Spergen Hill and in the region thereabout. Many of the corals, crinoids and other fossils that occur in this southern region never reached as far north as Bedford and Bloomington.

Ulrich expresses the belief that this is a pelagic fauna, and in his remarks concerning the reappearing of a part of this fauna in the Ste. Genevieve limestone states: "The writer does maintain, however, that the forms thus reappearing are members of a single slowly modifying and largely pelagic fauna that existed continuously elsewhere and entered this epicontinental basin only when conditions were favorable. One of these conditions involved the deposition of the oölitic limestones. Another probably was the

Plate VI.

Slab of Fossiliferous Limestone from Bloomington. About natural size.

subsidence or modification of barriers, allowing communication with seas more permanently inhabited by the invading fauna."*

The reappearance of a fauna with the re-establishment of favorable conditions is to be looked for in the formations of any epoch. This is most strikingly shown in regions where conditions favorable and unfavorable to a given fauna alternated through considerable lengths of time, as in the Pennsylvanian rocks of eastern Kansas. In the latter case, at least, the recurrence is faithfully repeated many times through over 2,000 feet of rocks. The modification of any one fauna throughout this great range is quite as gradual as that mentioned above, but, nevertheless, modification does exist, and to an appreciable extent, so that when the species are taken with regard to their relative abundance, their horizon can be determined. However it does not necessarily follow that such faunas are pelagic, and we are of the opinion that most of the "Spergen fauna" reappearing in the Ste. Genevieve rocks above referred to are not pelagic in the usual sense of that term.*

Our reasons for thinking so are: The Salem limestone is highly cross-bedded. The fossils, aside from exceptional localities, are waterworn and usually ground to fragments. Many of the fossils, including a large percentage of those enumerated by Ulrich, occur of normal size in the rocks above or below.

It seems to the authors that the cross-bedding of the rock, its water-worn fossils, the fact that they are stunted, and the oölitic or semi-oölitic character of the rock, wherever typically developed, precludes the idea of its pelagic origin and argues forcibly in favor of a semi-littoral or lagoonal origin, as is also indicated by its broadly lenticular occurrence, a condition unfavorable to the existence of billions of pelagic organisms through a considerable length of time.

In general the gastropods and brachipods found in the Salem limestone are forms indicative of shallow conditions, such forms as

*U. S. Prof. Pap. 36, p. 49, 1905.

*The following definition of the term pelagic as used in geology is given by the eminent paleontologist Felix Benard: "The idea of the pelagic facies [in geology] is broadened, and we refer to this facies the deposits formed in the deep sea, at a considerable distance from the shore, but not in the abyssal depths; they are characterized by the absence of the elements of the fauna of the littoral zone, and by a mixture of the forms adapted to swimming, such as cephalopods, pteropods, fishes, with creeping or fixed faunas (echinoderms, brachiopods, gastropods, Lamellibranchs), the species of which differ from those living near the shore." Translated by C. E. Brooks, from the 14th annual report of the State Geologist of New York. 1895.

might inhabit coral reefs and lagoons where there is considerable agitation of the water. The Bryozoa when perfect, as at Bedford, abound in strong brace roots, anchoring spines, and all the paraphernalia indicative of agitation of the water. The foraminifera and small ostrocods which are so conspicuous an element of the Salem fauna were swept in by currents from the open sea, as such pelagic organisms are now brought by the gulf stream to the coral banks of southern Florida. Their presence in a geological formation does not furnish any conclusive evidence one way or the other as to the littoral or pelagic origin of the fauna.

With the addition of the Bryozoa, *Zaphrentis cassedayi,* and a few other species, the fauna originally described by Hall may be considered as the typical fauna of the Salem limestone. Nevertheless any list of species, however complete, gives a very inadequate idea of the nature of the fauna as it really exists. It is only when the relative abundance of the species is graphically represented and their stunted condition kept in mind that the true conception of the fauna can be had and the characteristics brought out which at once sharply distinguish it from any other fauna of the Mississippian rocks.

The large part of the time was spent in the study of the corals, bryozoans, etc., not represented in the works of Hall and Whitfield. For their historic interest the original descriptions of Hall and the comments of Whitfield are given, as nearly as the advance of knowledge of the species will permit, in their original form.

All species described from this horizon, the "Warsaw" of Indiana, have been inserted here, so far as they have come to our notice. Those which have been studied are usually commented on except those represented in the original Hall collections, which have frequently been passed without comment.

No attempt has been made to determine the synonomy of species where no specimens of it were at hand for study.

Only the original description is mentioned in the bibliography of the species, as those of Weller, Schuchert and Nickles and Bassler cover the ground thoroughly and are available to all.

By force of circumstances and contrary to the usual custom, the chart showing the distribution and relative abundance of species will be given after the description of the fossils. Again, contrary to the usual custom, the discussion of the relationships of

this fauna to those of the subjacent and superjacent formations will be omitted until they have been more carefully studied and described.

The authors wish to express their obligations to the American Museum for the loan of specimens for comparison and study; to the National Museum for the loan of Bryozoa to compare with ours; to Mr. G. K. Greene for the loan of the Lanesville material in his collection and the valuable suggestions made; to Mr. R. S. Bassler, of the U. S. National Museum, for valuable suggestions in regard to the identification of several of the Bryozoa, and to the Indiana State Museum at Indianapolis for the loan of specimens.

Mention is due also to Messrs. L. C. Ward, A. W. Thompson, C. W. Shannon, T. E. Mason, C. T. Randolph and L. R. Gray, for valuable assistance in preparing and identifying material.

The drawings of this report were made by Miss Maud Siebenthal, of Bloomington, Indiana.

The authorship of the report is as follows:

Protozoa to Pentremites, J. W. Beede.
Paper on Pentremites Conoideus, Miss Essie A. Smith.
Echinoderma and Vermes, J. W. Beede.
Bryozoa, E. R. Cumings.
Brachiopoda and Pelecypoda, J. W. Beede.
Gastropoda to Crustacea, E. R. Cumings.
Vertebrates, Prof. E. B. Branson, Oberlin College, Oberlin, Ohio.

FORAMINIFERA.

ENDOTHYRA BAILEYI Hall.

Plate XXVI, figs. 34-36; Plate VII, fig. 1.

Endothyra Baileyi Hall, Trans. Albany Inst., IV, p. 34, 1856.

Specific Characters. A trifle more robust than *E. bowmani*.

"Shell depressed, orbicular, sub-equally convex above and below, smooth, margin rounded, indented by the septa; spire depressed, involved; last volution slightly oblique, consisting of eight loculi; aperture contracted. The general form of this fossil is depressed, globular, with the involutions deviating slightly from the same plane. Not infrequently, however, the spire ascends in greater or less degree, and one or more loculi become visible be-

yond the single volution. Sometimes seven loculi only are visible in the volutions. The surface is smooth under the ordinary magnifier, and the outline is indented at the septa."

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bedford, Bloomington, Harrodsburg, Elletsville and Stinesville. Found wherever the formation is typically developed.

ANTHOZOA (CORALS).

CYATHAXONIA VENUSTA Greene.

Plate XI, figs. 2-2a.

Cyathaxonia compressa Greene (non Thompson 1877), Cont. Ind. Pal., Vol. I, Pt. II, p. 9, pl. IV, ff. 14-17, 1899.

Cyathaxonia venusta Greene, Ibid, Pt. XIX, p. 187, pl. LVI, ff. 10-14, 1904.

Specific Characters.—Very slender, small, compressed corallum, straight, with high columella.

Corallum small, slender, straight, compressed and nearly smooth. Calyx elleptical, deep, with smooth slender columella projecting in the base. Primary septa reaching the central columella, the secondary uniting with the primary just before the columella is reached. Septa 30 to 36 in number. The union of the primary and secondary septa is less apparent at the top of the corallum than in sections nearer the base. Epitheca smooth, but showing small growth varices and longitudinal ridges corresponding to the septa. Height 14 mm., diameter of the calyx 4.5 mm. + 3.5 mm.

Localities.—Lanesville, Paynters Hill, Spergen Hill.

AMPLEXUS BLAIRI Miller.

Plate VIII, fig. 5.

Amplexus Blairi Miller (as figured by Keyes), Geol. Surv. Mo., IV, p. 108, pl. XXXIII, f. 1, 1894. Originally described by Miller, 17th Ann. Rep. Geol. Surv. Ind., p. 618, pl. I, f. 7, 1892.

Specific Characters.—Long, slender, tortuous corals, with strong, unevenly spaced tabulæ and stout short septa.

Corallum long, rather tortuous, rather slender, or nearly cylindrical. The tabulae are rather widely spaced and nearly flat or

slightly concave. Septa equal, about 30 in specimens 11 or 12 mm. in diameter, extending about .75 to 1 mm. toward the center. The epitheca is not shown on the specimen before me. Concerning the Missouri specimens Miller states: "The epithecal crust smooth and very strongly developed within the annulated depressions and much less distinct at the dilations." The "Annulations" referred to are probably strong growth varices. According to Miller the corallum "rapidly expands from a pointed base to the first dilation, where it bends abruptly upward."

Locality.—Edwardsville, Indiana. Specimen illustrated in the collection of Mr. G. K. Greene.

ZAPHRENTIS CASSEDAYI Milne-Edwards and Haime.

Plate VII. figs. 3-3c.

Zaphrentis Cassedayi Milne-Edwards and Haime, Hist. Nat. Corr. III, p. 341, pl. GI, f. 2, 1860.

Zaphrentis prona Milne-Edwards and Haime, Ibid., p. 342.

Zaphrentis spergenesis Worthen, Geol. Surv. Ill., VIII, p. 77, pl. X, f. 8-a, 1890.

Zaphrentis cassedayi Greene, Cont. Ind. Pal. I, pt. p.

Specific Characters.—Corallum small, long, slender, turbinate, spinous, with nearly circular cross action. Extremely deep calyx.

Corallum slender turbinate, attached or free, slightly arcuate to straight, sharply pointed (and frequently sharply bent) below. Calyx approximately circular, very deep; septa on its rim represented by low sharp lines, but extending to the center in the bottom of the calyx. Fossula large, deep and reaching to the center. At the margin of the calyx the primary and secondary septa are all of the same size, but are differentiated below; 44 to 48 in an adult specimen. Epitheca wrinkled and showing well defined longitudinal ridges corresponding with the interseptal spaces, the furrows marking the septa, which appear to split on joining the epitheca. Epitheca more or less thickly set with small spines, which point obliquely downward and appear in rows on the growth wrinkles. Sometimes these spines are almost wholly wanting.

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Elletsville, Stinesville and Romona.

Zaphrentis prona seems to have been described from a somewhat

arcuate specimen of this species without spines, while Worthen's figure represents a typical specimen of the species. Its small size and slender form will distinguish it from *Z. spinosa* of Hall. In external appearance it resembles, quite a little, *Lophophyllum profundum* M-E. and H., from the Coal Measures.

ZAPHRENTIS COMPRESSA Milne-Edwards and Haime.

Plate VII, figs. 4-4d.

Zaphrentis compressa Milne-Edwards and Haime, Hist. Nat. Corall., III, p. 342, pl. GI, ff. 3, 4, 1860.

Zaphrentis lanceolatus Worthen, Geol. Surv. Ill., VIII, p. 76, pl. X, ff. 4-4b, 1890.

Specific Characters.—Short, robust, compressed turbinate corallum, with about 20 to 24 primary septa in an average-sized individual.

Corallum straight or curved, turbinate compressed, pointed below. Calyx elleptical, rather deep, septa reaching about a third the way to the center at the top of the calyx and reaching to the fossula below. Fossula usually situated on the concave side of the corallum, deep, reaching to the center, around which the septa join. Primary septa 20 to 24. Secondary septa small but very distinct. Epitheca with faint longitudinal ridges when well preserved and faint growth lines.

Localities.—Spergen Hill, Paynters Hill, Lanesville.

ZAPHRENTIS CLINATUS Greene.

Plate XI, figs. 1-1c.

Zaphrentis clinatus Greene, Contr. Ind. Pal., Pt. XIX, p. 187, pl. 56, Figs. 6-9, 1904.

Original Description.—"Corallum simple, rather small, compressed, turbinate, regularly curved. Acute at the point of attachment. Height from 10 to 20 millimeters. Calyx oblique, from 10 to 15 millimeters in diameter. Depth 5 millimeters. A flat space in the bottom of the calyx, occupied by the tabulae 5 millimeters in diameter. Number of septa sixty-six in the circumference of a calyx, 20 millimeters in diameter, unequal in size at

the margin, alternating below, gradually sloping to the bottom of the calyx, where the short ones terminate, the longer ones continue to within 2 millimeters of the center of the calyx, and abruptly end, leaving a smooth, concave space 4 millimeters in diameter. Fossette consists of a deep depression in the center of the calyx and continues to the posterior margin. Exterior with moderately fine longitudinal striae, ten in the space of 5 millimeters. Surface comparatively smooth."

See Z. compressa M-E. and H. No specimens of this species have been examined.

BORDENIA Greene.

Bordenia Greene, Cont. Ind. Pal., I, pt. VII, p. 57, 1901.

"Corallum simple or composite, resembling Zaphrentis. Tabulae complete, with the central portion being smooth. Fossette well pronounced or scarcely more than rudimentary. Primary lamellae well defined. Secondary lamellae rudimentary or indicated by fine striae. Type B. Zaphrentiformis."

The fossils referred to this genus by Mr. Greene combine the characters to some extent of *Zaphrentis* and *Amplexus*. The regularity of the tabulae and the fact that the septa very rarely reach the center reminds one of *Amplexus*, while the fossula and the arrangement of the septa when they do reach the center, as they occasionally do, are well known characters of *Zaphrentis*. The genus Bordenia was erected to cover these combined characters, together with the character possessed by some of the specimens of calicular budding into a composite colony. Were it not for this latter character the specimens should be classed as an aberrant species of *Zaphrentis*.

BORDENIA ZAPHRENTIFORMIS Greene.

Plate VII, figs. 6-6c.

Bordenia zaphrentiformis Greene, Cont. Ind. Pal., I, pt. VII, p. 57, pl. XIX, ff. 2-9, 1901.

Corallum turbinate, robust, attached. Tabulae well developed, irregularly spaced and extending evenly across the corallum, turning down at the edges. Septa rather numerous, extending nearly

to the center, occasionally, but very rarely reaching it, frequently stopping at one-half to two-thirds the distance. There are 20 to 30 septa in adult individuals; secondary septa scarcely visible. There is no vescicular tissue in this species, but in cross section the turning down of the edges of the tabulae one above the other might be interpreted as such. The fossula is frequently hard to distinguish. The epitheca is well developed, with strong growth rings and rarely, slight longitudinal, rounded ridges, about two to the septum. The species increases by calicular budding into a composite colony.

Localities.—Lanesville, Paynters Hill, Spergen Hill.

The calicular budding, when present, and the presence of the fossula, when well developed, will at once distinguish this species from any other Carboniferous coral. From its general appearance it is more apt to be confounded with *Amplexus fragilis* or *A. blairi,* but the characters mentioned above and the longer septa will at once distinguish it.

ENALLOPHYLLUM Greene.

Enallophyllum Greene, Contr. Ind. Pal., pt. VII, p. 54, 1901.

"Corallum having tabulate area with vertical walls, resembling *Diphyphyllum,* and having a well developed fossette. Septa occur singly or in pairs, not extending farther than the vertical wall in the center of the calyx. Type *E. Grabaui.*"

ENALLOPHYLLUM GRABAUI Greene.

Plate VII, figs. 2-2d.

Enallyophyllum grabaui Greene, Contr. Ind. Pal., VII, p. 54, pl. 20, Figs 8-18, 1901.

Original Description.—"Corallum simple, or composite, increasing by gemmation from the superior margin to the parent cup, turbinate, straight or slightly curved. Acute at the point of attachment. Some examples have a broad scar at the base, some corallums have root-like prolongations that served for attachment and support. Exterior, when well preserved, exhibits numerous fine spines, distributed without any regularity, and frequently extends some distance on the side of the coral. Height varying in different individuals from 10 to 20 millimeters, or more in some

examples. Calyx somewhat expanded, from 8 to 10 millimeters in diameter. Depth 7 or 8 millimeters, walls nearly vertical. Situated in the center of the calyx is a vertical wall occupying one-third or slightly more than the corallum at that point. The tabulae is smooth and strongly oblique, occupying the entire inner area. Number of lamellae (septa) 54, in the circumference of a calyx 7 millimeters in diameter. Equal in size, and somewhat rounded at the margin, occurring in pairs except the single one that marks the continuation of the fossette, and three single ones on the opposite side to the fossette. Sometimes these three lamellae coalesce, and in some examples where the cup is well preserved they are not united, the lamellae extends to the vertical wall in the center of the calyx and abruptly terminates. The fossette consists of a deep depression at the margin of the smooth, oblique space in the center of the calyx, and continues some distance on the side of the coral, the position of the fossette is variable. I have examples with the fossette on the anterior and others having it on the posterior side."

Locality.—Lanesville, Indiana. Collection of G. K. Greene.

This species can be best understood as a Zaphrentis so modified that the inner part of the fossula is greatly enlarged and evenly tabulated throughout the length of the individual, the fossula proper being located at the side of the calyx.

CYSTELASMA Miller.

Cystelasma Miller, 17th Ann. Rep. Ind. Dept. Geol. and Nat. Res., p. 622, 1892.

"Corallum simple, irregularly turbinate or conical, consisting of an outer wall, transversely wrinkled or constricted, which is connected by oblique plates, irregularly disposed, that give to the interior cystose chambers of unequal size and irregular shape. No septa or regular tabulae. Structure vescicular. Type C. lanesvillense." To this diagnosis should be added the fact that some specimens show indications of rudimentary septa and some species show septa and others exhibit what appear to be rather regular tabulae.

CYSTELASMA LANESVILLENSE Miller.

Plate VIII, figs. 3-3d; Plate XI, figs. 3-3f.

Cystelasma lanesvillense Miller, Adv. Sheets, 17th Ann. Rep. Ind. Dept. Geol. Nat. Res., p. 13, pl. I, Figs, 15, 16, 1891. 17th Ann. Rep. Ibid, p. 623, 1892.

"Corallum simple, small, subcylindrical, attached by rootlets or by a basal pedicel, strongly wrinkled and constricted transversely; sometimes expanding rapidly from a small basal pedicel to the full size of the corallum, * * * or gradually expanding from rootlets. * * * Internal structure consisting of large and small cystose chambers or cavities, without any regular order, the walls being longitudinal, transverse and oblique, sometimes leaving the whole internal diameter of the corallum in a single chamber, and again dividing into two, three, four or more cavities, some of which are much larger and much more elongated than the others. The cavities in our specimens are empty or filled with calcite. There is no calyx, for the summit is open or divided by internal walls, showing incomplete cavities, and the same structure that exists below. There are no septa or true tabulae."

Localities.—Lanesville, Spergen Hill and Paynters Hill.

There are occasionally rudimentary septa shown in the walls of this species and slight external vertical ridges in the epitheca. Rudimentary ridges sometimes show on the inner walls of the calyx of well preserved specimens. There are a great variety of forms of this species. It was attached by cementing or rootlets and the form seems to be governed largely by the nature and stability of the support. The form is also greatly modified by the tendency to regeneration by calicular budding, in which the bud replaces the parent corallite, frequently changing abruptly the direction of growth and giving it a very rough, constricted outline, as shown in the figures. There is a more slender form grading into this one which may have had a firmer basis of attachment and grew proportionately more tall and smooth. It may also have been modified by the rapid accumulation of sediment about it. It shows all the characteristics of the former, however, even to anastomosing to some extent when they come in contact. I suspect that this latter characteristic is common to all the species of the genus.

There are in some of the specimens of this species a few, two to five, nearly vertical walls, but they are usually confined to the particular cyst in which they occur, though sometimes two cysts may have them in nearly the same planes.

CYSTELASMA SEPTATUM Greene.

Plate VIII, figs. 2-2d.

Cystelasma septata Greene, Cont. Ind. Pal., I, pt. VII, p. 56, pl. XIX, ff. 10-19, 1901.

Specific Characters.—Four or five vertical septum-like walls dividing the corallum into as many compartments, which are again subdivided into small cysts by more or less horizontal diaphragms usually confined by the two adjacent walls.

Turbinate Crystelasmas, slender or robust, smooth or highly wrinkled attached corallites. There are five, sometimes less, vertical walls having all the characteristics of septa passing from the base to the top of the corallite, reaching the center and dividing the specimen into radial compartments, which are subdivided into small cysts by horizontal or diagonal diaphragms confined to the compartment in which they occur. These cysts are small and very numerous. The epitheca is much as in the preceding species. Rarely a specimen shows indications of septa (smaller than the five) continuing through several cysts, but these are very rare.

Localities.—Lanesville, Paynters Hill and Spergen Hill. Specimens from Lanesville loaned by Mr. G. K. Greene.

A single specimen of this species shows a few smaller septa and is figured plate 19 Fig. 15. This specimen approaches in some extent the specimens figured, but not described, by Ulrich* under the names of *Cystelasma rugosum* and *C. quinqueseptatum*. I should not be surprised if very large amounts of material showed *C. septatum* and both of Ulrich's forms to be the same species.

*U. S. Prof. Pap. 36, Plate 5, Figs. 12a-g. These specimens are neither described nor do they have the internal characters shown. They do not deserve recognition at all as described species and the writer is aware that he is violating the rules governing such cases in giving him credit for the name used to designate the following species.

CYSTELASMA RUGOSUM Ulrich.

Plate VII, figs. 5-5b.

Cystelasma rugosum Ulrich, U. S. Prof. Pap. 36, p. 46, pl. V. ff. 12a-g, 1905.

Specific Character.—A Cystelasma, like *C. septatum,* but with 16 or 18 septa.

Corallum of average size for the genus, bluntly turbinate, attached and constricted. Septa 5 primary and 16 or 18 secondary extending through the larger part or all of the corallite. Epitheca with faint longitudinal striae ribs over septa. In all other respects it is like *C. septatum,* and may be a variation of it.

Locality.—Paynters Hill. Specimens figured belong to the Indiana University collection.

I can not be certain that this species is the same as the one figured but not described by Ulrich previously mentioned, but from general appearances there would seem to be no question as to their specific identity.

CYSTELASMA TABULATUM n. sp.

Plate VIII, figs. 1-1c.

Specific Characters.—Five "septa" reaching a third the way to the center and tabulae reaching pretty evenly across the corallite.

Corallum of medium size, tortuous and constricted. Tabulae numerous, rather evenly spaced and nearly horizontal. Septa five, extending the entire length of the specimen and reaching about a third the way to the center. No other dissepimental tissue. Epitheca thin and, on the two specimens at hand, smooth except for the growth annulations. They probably possess finer markings, but are not preserved on our specimens.

Locality.—Spergen Hill. Types in the Indiana University Museum.

This species might be placed with Amplexus if its habit, appearance and associates were not considered. However, I am satisfied that it belongs to a distinct phylum. It has all the appearance of the Cystelasmas, with which it occurs, the five septa, common to all the species but one, and that one shows this structure

occasionally in single large cysts, which occupy the entire diameter of the corallum.

It seems to be most closely related to *C. lanesvillensis*, the diagonal walls of which have become horizontal and the five septum-like ridges, sometimes seen, developed into the five septa as seen in the types.

It may seem to be stretching a generic description somewhat to include in it species with both septa and tabulae when it expressly states that it contains neither. However, Ulrich has rightly pointed out that there are sometimes indications of rudimentary septa present in the type species. The tabulae in this species may be regarded as the dissepimental walls of the type species arranged more horizontally, some of which, even in *C. lanesvillensis* pass almost horizontally across the cavity of the body.

SYRINGOPORA MONROENSE n. sp.

Plate IX figs. 1-2; Plate X, figs. 1-2; Plate XI, figs. 7-7f.

Specific Characters.—Absence of connecting bars, robust corallites budding rather indiscriminately above the base, thickened walls like Monilopora, but often having crowded tabulae, somewhat like Syringopora. Barely anastomosing when the thickly set corallites come in contact.

Corallum large, spreading, nearly flat on top, the base first spreading like aulopora until about the size of a small saucer and becoming very thick with corallites when they turn upward in a dense colony. The vertical tubes occasionally give off buds, sometimes two at the same level, but this is more or less accidental unless the growth of the colony is interfered with. In such cases the buds may be given off of most of the corallites at the same level. The colonies are frequently two inches in depth. The tubes are large for the genus, thickly set, but the circular nature of the calyx is never made angular by the contact of corallites. The interior of the tube is filled to a considerable extent below with secondary deposit from within. (The semi-silicified nature of these specimens is such that satisfactory thin sections can not be made of them.) In some tubes there are thickly set tabulae sagging in the middle, but not funnel-shaped as in typical Syringoporas. In other tubes there seem to be no tabulae whatever.

In one case vesicular tissue was seen in one of the tubes, which is represented on the plate of drawings.

Localities.—Lanesville (three specimens from State Museum), types from Bloomington, and in the Indiana University collection.

This species is intermediate in many of its characters between Syringopora and Monilopora. Its habit of growth and abundant concave tabulae (not present in all tubes) are characteristic of Syringopora. On the other hand, the absence of cross bars connecting the corallites, the deposition within the lower part of the tubes, and absence in some tubes of many tabulae are characters usually ascribed to Monilopora.

The characters which seem to separate this species from Syringopora will distinguish it from the species of that genus, while those separating it from Monilopora will equally distinguish it from the known species of that genus.

After a long discussion of the subject Girty* concludes that the families of this group of corals need a thorough revision in the light of new material. I certainly agree with him in this respect. Meanwhile I think it best to refer material to already described genera instead of describing a new genus for each case arising and thus adding to the confusion.

MONILOPORA BEECHERI Grabau.

Plate XI, figs 6-6a

Monilopora beecheri Grabau, Proc. Bost. Soc. Nat. Hist., XXVIII, p. 411, pl. I, ff. 2, 3, pl. II, ff. 1-5, 1899.—Cont. Ind. Pal. I, pt. VII, p. 50, pl. XIX, ff. 20, 21, 1901.

Original Description.—"Corallum regularly branching or forming a confused mass of intergrown tubes, which branch and repeatedly unite, the calices opening in all directions. Tubes expanding rapidly towards the calyx, below which they give off more lateral buds. Adjoining corallites frequently united by their walls. Walls thick, especially in the lower portion of the corallites, consisting of numerous concentric lamellae, between which the reticulate structure appears. The lacunæ are subequal, but the lamellae separating them are more irregular, and as a rule thicker

*U. S. Prof. Pap. 16, p. 325, 1903.

than those of *M. crassa*. The trabeculae are also more irregularly disposed."

Localities.--Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Elletsville.

"This species differs from the described and figured forms of *M. crassa* in the larger size of its corallites, the more confused growth of the agglomerate mass, and the greater length and more regular budding of the simple branches. The internal differences appear to be the irregularities of the reticulate tissue, which also is much less frequently developed. From *M. antiqua* it differs chiefly in its surface features, and in the thickness of the wall, which in that species is stated to be 'rather thin.' "

"The regular coralla give off calices at definite intervals, these calices pointing upward and outward on all sides. From this it appears that the regular coralla grew upright, unsupported except basally. The more usual method of growth, however, seems to have been by irregular budding, which resulted from the attachment of the young coral to the crinoid stem. Such an attached individual would not require the regular growth, which is necessary in the free corallum to maintain proper balance, and hence the attached corallum put out buds promiscuously."

None of the attached colonies appear in our collection, probably for the reason that there was nothing of any considerable size to attach to; the conditions varying much from the crinoid beds at Crawfordsville, from which the types were taken. Some specimens, shown in the photographic plate,* grew around some circular or cylindrical object, apparently too weak for support, so that instead of forming an attached mass it grew away again, leaving a row of calices growing directly away from the support. Our specimens agree very well with the figures and description of the free specimens from the type locality, show about the same amount of thickening of the lower portions of the tubes, but the reticulate tissue seems to be more sparingly developed. However, it occurs occasionally. The specimens from this horizon are either too coarsely silicified to show anything of the microscopic structure or are partially silicified, making sectioning in a satisfactory manner nearly impossible.

*Since this was written the plate was discarded.

One point in which an occasional specimen differs from the types is shown on the halftone plate;* that is, in showing a tendency to regeneration by calicular budding, the new bud replacing the old one and filling the old calyx. Sometimes these originate on or near one side and again seem to originate centrally.

CERATOPORA AGGLOMERATA Grabau.

Plate XI, figs. 5-5a.

Ceratopora agglomerata Grabau, Contr. Ind. Pal., Pt. VII, p. 51, pl. 19, figs. 22-25, 1901.

Original Description.—"Corallum compound, consisting of agglomerate masses, unattached except basally. Corallites auloporoid, slightly curved, and gradually enlarging towards the aperture, which is circular. A short distance below the termination of the corallite one or two buds are given off, diverging at various angles; sometimes extending acutely upward; frequently at right angles to the parent, or occasionally extending downward. The buds themselves give off other buds, which may extend in all directions. Corallites frequently joined by epithecal prolongations. Interior with circumferential cysts. Cysts rather sparingly developed, but usually of fair size. Septal spines small, short and comparatively stout; in numerous vertical rows.

"This species is readily recognized by its singular branching corallites, which form a confusedly agglomerate mass. The frequent rectangular branching divergence of the beds from the parent gives rise to masses in which corallites of the third generation may grow in a diametrically opposite direction from that taken by the corallites of the first generation. Sometimes from crowding a bud may grow in such a direction as to form a complete loop with its parent corallite. Not infrequently a number of corallites, budding one from another, appear to form a ring around a corallite of an earlier generation, which occupies the center.

"No case has been observed where there are more than two buds given off at the same level, this being the usual number. In this respect the species is like *C. dichotoma* Grabau, but the buds are irregular, as in *C. distorta,* Grabau. In some corallites, however, a second series of buds are given off at a higher level, and these, rebudding again, greatly increase the complexity of the whole

*Since this was written the plate has been discarded.

corallum. In some cases, however, the corallites grow to a considerable length after giving off their first pair of buds, without producing a second series. While the buds are most frequently given off in pairs, the two are not always given off at precisely the same level, there being often a slight discrepancy between them. This feature is occasionally seen in *C. dichotoma,* the most regular species of the genus, and is common in *C. distorta.*

"When the corallites are united by the epithecal prolongations, a rugose surface is produced from the wrinkled character of the epitheca. Otherwise the surface is smooth, showing only fine concentric growth lines. When the corallites grow close together they generally become inseparably united, and not infrequently the original circular section of the tube will be variously modified or distorted, and often become concave on the side of contact.

"The less frequent development in this species of the cyst is a characteristic feature. They are best visible in the calicinal portions, for as the known specimens of this species are all silicified, the interior structure has become more or less modified, and some of the cysts have been filled. There is, as in all the species of the genus, a complete absence of tabulae, the corallites remaining open throughout and united to their parent basally at least during the greater part of life. In many individuals the connecting pore is probably never closed, in others a sort of partition is formed over it by the extensive growth of spines. When the daughter corallite becomes separated from the mother tube the pore may be covered by the formation of a cyst wall over it. Occasionally adjoining corallites have been found to be traversed by a single pore, this undoubtedly being a case of aborted budding. The septal spines appear generally much shorter than in the Devonian species in this respect, and in the diminution of the cysts, approaching Monilopora. In a few cases, however, spines comparable to those of *C. dichotoma* and *C. distorta* have been observed. In some cases the interior of the wall appears perfectly smooth, the fine papillose spines being probably destroyed during the process of crystallization.

"This species is closely related to *C. distorta* Grabau, but I do not think that the two are identical. The profusely branching specimen figured on plate 3, Fig. 7, Vol. 28, Sp. 16, Boston Soc. Nat. Hist. Proceedings, and referred to *C. distorta*, has many char-

acters of the present species, and forms a connecting link between the two. Though parallelisms in form occur, the structure of the two species is sufficiently distinct. The present species is also somewhat smaller than the prevailing forms of *C. distorta.*"

Horizon and Localities.—"In the Warsaw Division of the St. Louis Group, Lower Carbonian; Lanesville, Harrison County, Indiana."

PROTOPORA Greene.

Protopora Greene, Cont., Ind. Pal., pt. XVII, p. 169, 1904.

"Corallum composite, increasing by lateral and calicular gemmation. Corallites frequently connected by their epithecal walls, and having numerous transverse and oblique diaphragms which divide the tubes into coarse cysts somewhat like Cystelasma, but differing from Cystelasma in having mural pores in the adjoining corallites as in Romingeria. Type *P. Cystoides.*"

Grabau states concerning *Romingeria cystoides:* "These diaphragms, together with the absence of septal spines, and general rugose corallum, separate this species from the others of the genus, and may make it desirable to place it in a distinct genus. These features closely ally the present species to *Cystelasma,* S. A. Miller, of which the type *C. Lanesvillense* occurs in the Warsaw group of Indiana. This genus, however, is stated to be simple, while the present species has the compound mode of growth and mural pores of Romingeria. Under this genus it will be left for the present, until better preserved material allows the making of sections for the closer study of the internal structure."

PROTOPORA CYSTOIDES (Grabau).

Plate XI, 4-4d.

Romingeria cystoides Grabau, Cont. Ind. Pal., I, pt. VII, p. 52, pl. XX, ff. 19-23, 1901.

Protopora cystoides Greene, Contr. Ind. Pal., I, pt. XVII, p. 169, 1904.

"Corallum compound, erect, free except basally, consisting of numerous more or less closely crowded corallites, which usually proceed in an unbelliferous manner from the parent corallite. Corallites elongate-conical to sub-cylindrical, widening at first rapidly,

then more slowly, and finally retaining almost the same diameter throughout. Calicinal portion not infrequently inflated.

"Corallites closely adnate for the greater part of their length, and connected by mural pores. Septa absent so far as known. Interior traversed by irregular lamellae, which extend across the cavity and frequently join each other, dividing the visceral chamber into a number of cysts."

Locality.—Lanesville.

"This species is readily recognized by its rather coarse though not large corallites, the mural pores and the irregular diaphragms which take the place of tabulae. The corallites bud off from the parent in verticils of three or more, and they grow upward, closely adhering to the old corallites, which also continue to grow and to embrace each other. They are closely united by the epitheca, which in some cases extends across several corallites, and in others effects the junctions merely by root-like proliferations. The epitheca is wrinkled and the growth lines are strong, and this, with the frequent constrictions of the corallites, gives them a very rough and wrinkled appearance. The direction of growth is upward in most cases, but in some colonies it is more irregular, the corallites growing loosely. In such cases the unbelliferous habit is generally lost sight of."

The drawings, plate XI, Figs. 4, 4a, were made from specimens loaned by Mr. G. K. Greene, who has the types, and whose identification of these specimens is used.

MICHELINIA INDIANENSIS n. sp.

Plate XI, figs. 8-8a.

Specific Characters.—Conical or taller habit, very small corallites, with large number of young or undersized ones, thin walls.

Corallum irregularly conical, small, base unknown. Corallites small, very deep and many angled like Favosites, and varying in size with age. The largest corallites are 2¼ mm. in diameter. There are about two small corallites to one well developed one. The walls are very thin and the edges of the corallites proportionately sharp. The mural pores are fairly abundant and large, the scale-like tabulae frequently developed as little awnings over the pores, though in the older part of the corallite they occur inde-

pendent of the pores and are very numerous. There are six to eight corallites per centimeter.

Locality.—Lanesville. Type specimens in the collection of G. K. Greene.

This species is very closely allied with what Ulrich has figured but not described as *M. eugeneae var princetonensis* from a higher horizon. However, he has not described his "variety," and our specimens differ from his figures in having thin walls instead of thick ones and in being a much more delicate colony with smaller cells and a larger percentage of immature ones. These characters will at once separate it from *M. eugeneae* and probably from Ulrich's variety.

PALÆACIS CUNEIFORMIS Milne-Edwards and Halme.

Plate VIII, figs. 4-4i.

Specific Characters.—Cuneate corallum with corallites all in one plane, with crenulated surface marks.

Corallum cuneiform, key-shaped, free, higher than wide and rather sharp below, rounded at the edges. Sometimes, however, the base may be rather blunt and taper nearly to a point. The form of the specimens of this species is very variable. The specimens thicken and expand laterally until the region of the corallites is reached, when they rapidly contract, making the specimen paddle-shaped or key-shaped. The calices are large, long-elliptical to nearly circular and fairly deep. They are two to five, depending on the age of the corallum, alternately spaced, extending obliquely inward and downward. When first developed each calyx is placed a little to one side of the middle of the coeallum. The inner surface of the calices is coarsely punctuate, the punctae, being located in slight depressions, produce a slightly pustular surface. There is also a faint ridge passing up the inner or back side of the cavity. The ridges forming the surface markings of the specimen, terminating at the margins of the openings, give them a crenulated periphery. The surface ornamentation consists of wavy ridges closely set and minutely crenulated, extending obliquely inward and downward.

Localities.—Spergen Hill, Paynters Hill.

DEVELOPMENT AND VARIATION OF PENTREMITES CONOIDEUS.

BY ESSIE ALMA SMITH.

Up to the present time very little has been done toward the study of the development of Pentremites, and until recently there had not been any very comprehensive study of the anatomy of the Blastoid group. Perhaps one reason for this neglect is the fact that there are no living representatives of this group, and a study of it must necessarily be difficult, because such a study must be based entirely upon the fossil specimens. Prof. G. Hambach, of Washington University, has given a series of drawings* showing the development of the deltoid pieces in *Pentremites sulcatus.*

The present writer has attempted to make a study of the development and variation of *Pentremites conoideus,* and from this study and a comparison of the young of *P. conoideus* with *Codaster sp.* from the Hamilton formation there has been found at least a hint as to the possible ancestry of *Pentremites.* Another point which this study has incidentally brought out is a suggestion as to the possible cause of the dwarfing of the fauna of the Salem limestone. The writer has also discovered specimens in the series studied which seem to prove that there are plates or septa in the oral opening of *P. conoideus.*

The material used in this investigation includes more than 5,700 specimens. About 980 specimens are in the Indiana University Geological Museum, 354 specimens belong to the State Museum, and Mr. G. K. Greene has kindly loaned about 4,400 specimens from his fine collection.

The specimens used in the investigation came from the Lower Carboniferous series, and from eight localities, as follows: Four thousand seven hundred specimens from Lanesville, Ind. (Salem limestone); over 276 specimens from the old Cleveland quarry, near Harrodsburg, Ind. (upper part of Salem limestone); 240

*"A Revision of the Blastoideae." Trans. Acad. Sci. of St. Louis. Vol. xiii, Plate vi.

specimens from Pentremite Hollow, south of Bloomington, Ind. (upper part of the Harrodsburg limestone); 165 specimens from Spergen Hill, Ind. (Salem limestone); 150 specimens from Paynter's Hill, Ind. (Salem limestone); 48 specimens from the Big Creek quarries, near Stinesville, Ind. (Salem limestone); 40 specimens from Hunter Valley, northwest of Bloomington, Ind. (Salem limestone); and over 40 specimens from the Matthews quarry, Ellettsville, Ind. (Salem limestone.)

The study is based upon the measurement of 735 specimens, upon the microscopic examination of over a dozen small specimens, the distal ends of which had not been preserved, and upon the careful examination of the rest of the material. The 735 specimens which were measured and the small specimens which were microscopically examined, are in the Indiana University Geological Museum.

The writer takes this opportunity to express her thanks to Mr. G. K. Greene for the specimens which he kindly loaned, and to Dr. E. R. Cumings for the accompanying photographs. During the prosecution of this study the writer has received much encouragement and many valuable suggestions from Drs. E. R. Cumings and J. W. Beede. For this encouragement and these suggestions the author is deeply grateful.

A great deal of the material in the University Geological Museum, especially that from Harrodsburg and Pentremite Hollow, was collected in a manner which almost entirely eliminates the personal equation. The collector shoveled up the material just as it had been weathered from the rock. It was brought into the laboratory, where it was washed through three sieves, each having a different sized mesh. Three grades of material—coarse, medium and fine—were thus obtained. This material was then carefully looked over with the aid of a reading glass and lens, and all of the Pentremites seen were picked out for study. Of the specimens which were measured, those from Harrodsburg and from Pentremite Hollow have been of the most value and interest in this study, first, because the series from these localities are more complete, and, second, because the specimens from Harrodsburg are dwarfed and those from Pentremite Hollow are normal. For this latter reason they lend themselves admirably to the study of the dwarfing of the fauna of the Salem limestone.

The method of investigation consisted in counting the number of poral pieces in each of the 735 specimens, in making certain careful measurements of these specimens, and in a general study of all of the material. The smallest specimens used in this investigation contained no poral pieces. The distal portion had not been preserved and the writer is doubtful if some of the smallest of these specimens ever possessed poral pieces.

The measurements taken in addition to counting the number of poral pieces, were, first, the relative length of the ambulacral area (a) (See Fig. 1), and the radius of the base (b), and the ratio of the length of the ambulacral area to the radius of the base; second, the measurement of the angle (c), formed by the

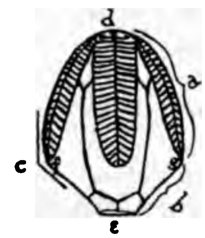


Fig. 1.

juncture of the ambulacral area and the base; third, the length of the entire specimen, from (d) to (e); and fourth, the breadth of the specimen from (f) to (g). The ratio of length to breadth was obtained by dividing the length by the breadth. All measurements were made with a millimeter scale, with the exception of the angle measurement, which was made with a contact goniometer.

The data thus obtained have been arranged by localities. They have been further arranged according to the number of poral pieces. The original data, being somewhat lengthy, have been shortened by averaging all of the measurements of specimens having the same number of poral pieces. Below are given the data:

HARRODSBURG—CLEVELAND QUARRY.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.*		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
5	3	.62 + : 1.91 + mm	.37 +	109°	2.22 + mm	1.73 mm	1.28 +
19	4	.92 + : 1.86 + mm	.49 +	111°	2.52 + mm	2.16 mm	1.16 +
11	5	1.06 + : 1.84 + mm	.57 +	115°	2.74 + mm	2.23 + mm	1.22 +
15	6	1.46 + : 2.31 + mm	.63 +	114°	3.26 + mm	2.75 mm	1.18 +
21	7	1.78 + : 2.42 + mm	.73 +	116°	3.52 + mm	3.01 + mm	1.16 +
16	8	2.04 + : 2.43 + mm	.83 +	116°	3.75 mm	3.25 mm	1.15 +
12	9	2.33 + : 2.55 + mm	.91 +	118°	4.08 + mm	3.35 + mm	1.21 +
18	10	2.51 + : 2.78 + mm	.90 +	118°	4.46 + mm	3.58 + mm	1.24 +
16	11	2.76 + : 2.68 + mm	1.02	117°	4.62 + mm	3.78 + mm	1.22 +
15	12	3.00 + : 2.76 + mm	1.08 +	118°	4.96 + mm	3.95 + mm	1.23 +
13	13	3.38 + : 2.91 + mm	1.16 +	118°	5.32 + mm	4.18 + mm	1.27 +
20	14	3.70 : 2.88 + mm	1.28 +	118°	5.60 mm	4.43 + mm	1.26 +
15	15	3.81 + : 2.93 + mm	1.30 +	115°	5.71 + mm	4.56 + mm	1.25 +
16	16	4.34 + : 3.32 mm	1.30 +	117°	6.15 + mm	4.84 mm	1.27 +
9	17	4.66 : 3.17 + mm	1.47	116°	6.38 + mm	5.11 mm	1.24 +
5	18	4.60 : 3.17 mm	1.45 +	119°	6.45 mm	5.05 mm	1.27 +
8	19	5.14 : 3.31 + mm	1.55 +	116°	6.87 + mm	5.34 + mm	1.28 +
10	20	5.60 : 3.55 mm	1.57 +	116°	7.37 + mm	5.54 + mm	1.33 +
5	21	5.76 + : 3.36 + mm	1.71 +	115°	7.23 + mm	5.55 mm	1.39 +
9	22	6.20 + : 3.66 + mm	1.69 +	116°	8.25 + mm	6.11 mm	1.35 +
3	23	6.75 : 3.66 + mm	1.84 +	113°	8.22 mm	6.50 mm	1.26 +
3	24	7.11 : 4.16 + mm	1.73 +	119°	9.28 mm	6.83 + mm	1.35 +
4	25	7.25 : 3.81 + mm	1.90 +	115°	8.87 + mm	6.41 + mm	1.38 +
1	26	8.00 : 4.50 mm	1.77 +	120°	10.50 mm	7.50 mm	1.40
3	28	8.00 : 4.00 mm	2.00	113°	9.66 + mm	7.00 mm	1.38
2	29	9.50 : 4.50 mm	2.11	113°	12.00 mm	7.50 mm	1.60
1	31	10.50 : 5.00 mm	2.10	110°	12.00 mm	8.00 mm	1.50
1	34	11.00 : 4.50 mm	2.44 +	108°	11.50 mm	8.50 mm	1.35 +

*The first column of numbers under this heading represents the absolute length of the ambulacral area; the second column represents the absolute length of the radius of the base; and the third column is the result obtained by dividing the figures in the first by those in the second column.

BLOOMINGTON—PENTREMITE HOLLOW.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.*		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
1	8	2.00 : 2.50 mm	.80	112°	4.00 mm	3.50 mm	1.14
1	10	2.50 : 3.00 mm	.83 +	114°	4.00 mm	4.00 mm	1.00
2	11	2.75 : 3.00 mm	.91 +	117°	4.75 mm	4.00 mm	1.18 +
4	12	3.18 : 3.06 + mm	1.03 +	115°	5.00 mm	4.25 mm	1.17 +
3	13	3.36 + : 3.00 mm	1.12	115°	5.44 + mm	4.72 mm	1.15 +
4	15	4.25 : 3.25 mm	1.30 +	113°	6.00 mm	5.00 mm	1.20
1	16	4.50 : 3.50 mm	1.28	98°	5.00 mm	6.00 mm	.83
4	17	5.25 : 3.91 + mm	1.34 +	113°	6.81 + mm	5.79 mm	1.17 +
5	18	5.10 : 3.35 mm	1.52 +	115°	6.93 mm	5.80 mm	1.19 +
8	19	5.59 + : 3.65 + mm	1.53 +	110°	6.87 + mm	6.03 + mm	1.13 +
6	20	5.86 : 3.83 + mm	1.53	111°	7.30 + mm	6.30 + mm	1.15 +
8	21	6.25 : 3.84 + mm	1.63 +	110°	7.58 + mm	5.81 + mm	1.30 +
7	22	6.73 + : 4.07 + mm	1.65 +	112°	8.02 + mm	7.04 + mm	1.13 +
10	23	6.92 + : 4.12 + mm	1.67 +	111°	8.01 + mm	6.92 mm	1.30 +
6	24	7.20 + : 3.91 + mm	1.81 +	108°	8.52 + mm	7.16 + mm	1.18 +
4	25	7.12 + : 4.00 mm	1.78	109°	8.25 mm	7.00 mm	1.17 +
8	26	8.31 + : 4.56 + mm	1.82 +	109°	9.27 mm	7.93 + mm	1.16 +
5	27	8.25 : 5.00 mm	1.61 +	110°	9.20 mm	7.93 + mm	1.15 +
4	28	8.66 + : 4.75 mm	1.82 +	103°	9.87 + mm	8.50 mm	1.16 +
6	29	8.52 + : 4.75 mm	1.79 +	109°	9.66 + mm	8.00 mm	1.20 +
10	30	9.01 + : 4.67 + mm	1.95 +	102°	9.56 + mm	7.71 + mm	1.23 +
7	31	9.64 : 5.00 mm	1.92 +	104°	10.25 mm	9.03 + mm	1.13 +
10	32	9.70 : 4.97 + mm	1.95 +	105°	10.20 mm	8.85 mm	1.15 +
8	33	10.50 : 5.14 + mm	2.04 +	104°	10.85 + mm	8.12 + mm	1.33 +
5	34	10.60 : 5.50 mm	1.92 +	106°	11.50 mm	9.80 mm	1.17 +
11	35	11.11 + : 5.54 mm	2.00 +	104°	11.63 + mm	9.77 + mm	1.19 +
10	36	11.70 : 5.45 mm	2.14 +	101°	11.85 mm	10.25 mm	1.15 +
4	37	12.06 + : 5.68 + mm	2.12 +	108°	12.87 + mm	10.25 mm	1.25 +
10	38	12.45 : 5.95 mm	2.09 +	105°	12.90 mm	10.81 + mm	1.19 +
6	39	12.75 : 5.83 + mm	2.18 +	105°	13.08 + mm	10.20 + mm	1.28 +
12	40	12.58 + : 6.25 mm	2.01 +	107°	13.75 mm	10.87 + mm	1.26 +
5	41	13.75 : 6.63 mm	2.07 +	103°	13.90 mm	12.10 mm	1.14 +
5	42	14.00 : 6.70 mm	2.08 +	107°	14.70 mm	11.90 mm	1.23 +
4	43	14.00 : 6.50 mm	2.15 +	103°	14.12 + mm	11.75 mm	1.20 +
6	44	15.25 : 6.25 mm	2.44	104°	15.16 + mm	11.91 + mm	1.28 +
9	45	15.66 + : 6.77 + mm	2.31 +	106°	15.61 + mm	12.50 mm	1.24 +

*See preceding footnote.

BLOOMINGTON—PENTREMITE HOLLOW—Continued.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.*		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
2	46	16.00 : 6.50 mm	2.46 +	101°	16.00 mm	12.00 mm	1.33 +
2	48	16.00 : 7.00 mm	2.28 +	106°	15.75 mm	11.50 mm	1.36 +
3	49	16.66 + : 6.83 + mm	2.41 +	103°	17.16 + mm	12.50 mm	1.37 +
6	50	17.19 + : 7.08 + mm	2.42 +	104°	17.22 + mm	13.20 + mm	1.38 +
3	52	17.66 + : 6.66 + mm	2.65 +	103°	17.40 mm	12.00 mm	1.45
2	56	18.50 : 7.00 mm	2.64 +	98°	17.00 mm	13.25 mm	1.28 +
1	58	21.00 : 7.00 mm	3.00	104°	20.00 mm	14.00 mm	1.42 +
1	59	21.00 : 8.00 mm	2.62 +	104°	21.00 mm	15.00 mm	1.40
1	63	23.00 : 8.00 mm	2.87 +	101°	22.00 mm	16.00 mm	1.36

SPERGEN HILL.

1	6	1.50 : 2.33 mm	.64 +	112°	3.33 mm	3.00 mm	1.11
2	7	1.75 : 2.37 + mm	.73 +	114°	3.58 mm	3.12 + mm	1.14 +
1	8	2.00 : 2.25 mm	.88 +	115°	3.50 mm	3.00 mm	1.16 +
1	9	2.00 : 2.25 mm	.88 +	115°	3.50 mm	3.00 mm	1.16 +
1	10	2.50 : 2.50 mm	1.00	117°	4.33 mm	3.50 mm	1.23 +
1	11	3.00 : 3.00 mm	1.00	118°	5.00 mm	4.00 mm	1.25
4	12	3.12 + : 2.93 + mm	1.06 +	119°	5.16 + mm	4.00 mm	1.29
2	13	3.75 : 3.50 mm	1.07	120°	6.00 mm	4.75 mm	1.26 +
6	14	3.90 + : 3.00 mm	1.30	117°	5.45 mm	4.54 + mm	1.17 +
4	15	4.31 + : 3.12 + mm	1.38 +	120°	6.18 + mm	4.81 + mm	1.49 +
7	16	4.52 + : 3.47 + mm	1.31 +	109°	6.05 + mm	5.48 + mm	1.10 +
10	17	4.94 + : 3.32 + mm	1.48 +	112°	6.28 + mm	5.38 + mm	1.16 +
6	18	5.23 + : 3.46 + mm	1.51 +	112°	6.70 + mm	5.56 + mm	1.20 +
5	19	5.40 : 3.75 mm	1.44	114°	7.28 mm	5.95 mm	1.22 +
11	20	5.83 + : 3.81 + mm	1.53 +	110°	7.07 + mm	6.29 + mm	1.12 +
12	21	6.01 + : 3.64 + mm	1.65 +	110°	7.22 + mm	6.27 + mm	1.15 +
6	22	6.16 + : 3.45 + mm	1.78 +	112°	7.50 mm	6.02 + mm	1.22 +
16	23	6.51 : 3.78 + mm	1.72 +	109°	7.80 mm	6.79 + mm	1.14 +
8	24	6.93 + : 3.81 + mm	1.81 +	103°	7.81 + mm	6.65 + mm	1.17 +
5	25	7.20 : 3.75 mm	1.92	108°	8.26 mm	7.10 mm	1.16 +
1	26	7.00 : 4.00 mm	1.75	102°	9.00 mm	7.50 mm	1.20
2	27	7.50 : 4.50 mm	1.66 +	107°	8.37 + mm	7.75 mm	1.08 +

*See preceding footnote.

STINESVILLE—BIG CREEK QUARRY.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.[a]		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
1	5	1.25 : 2.25 mm	.55 +	113°	3.00 mm	2.25 mm	1.33 +
1	6	1.50 : 2.25 mm	.66 +	121°	3.00 mm	2.33 mm	1.28 +
4	7	1.68 + : 2.18 + mm	.77 +	116°	3.18 mm	2.55 mm	1.24 +
5	8	2.00 : 2.43 + mm	.81 +	113°	3.70 mm	3.13 + mm	1.18 +
3	9	2.46 : 2.66 + mm	.92 +	119°	4.00 mm	3.22 mm	1.24 +
4	10	2.47 + : 2.62 + mm	.94 +	120°	4.12 + mm	3.31 + mm	1.24 +
2	11	2.50 : 2.25 mm	1.11 +	118°	4.00 mm	3.37 + mm	1.18 +
3	12	3.00 : 2.91 + mm	1.03 +	121°	5.00 mm	4.00 mm	1.25
2	13	3.16 + : 2.75 mm	1.14 +	116°	5.16 + mm	4.20 mm	1.22 +
3	14	3.58 + : 2.83 + mm	1.26 +	114°	5.16 + mm	4.41 mm	1.17 +
1	15	3.75 : 2.50 mm	1.50	115°	5.00 mm	4.00 mm	1.25
4	16	4.06 + : 3.00 mm	1.35 +	118°	5.75 mm	4.43 + mm	1.29 +
3	17	4.75 : 3.16 + mm	1.50	119°	6.50 mm	5.33 + mm	1.21 +
1	18	4.50 : 3.00 mm	1.50	116°	5.50 mm	5.00 mm	1.10
3	19	5.11 : 3.72 mm	1.37 +	117°	7.11 mm	5.83 mm	1.21 +
1	20	5.00 : 3.25 mm	1.45 +	113°	6.66 mm	5.50 mm	1.21 +
1	21	6.00 : 3.50 mm	1.70	118°	7.50 mm	6.00 mm	1.25
1	22	6.00 : 3.50 mm	1.70	117°	7.50 mm	6.00 mm	1.25
1	24	7.00 : 3.50 mm	2.00	120°	8.00 mm	7.00 mm	1.14 +
1	27	7.50 : 3.25 mm	2.00	119°	10.00 mm	8.00 mm	1.25
1	30	8.00 : 3.50 mm	2.28 +	114°	9.50 mm	6.50 mm	1.46 +
1	32	11.00 : 6.00 mm	1.83 +	113°	12.50 mm	9.50 mm	1.31 +
1	33	11.00 : 6.00 mm	1.83 +	116°	12.00 mm	9.25 mm	1.28 +

BLOOMINGTON—HUNTER VALLEY.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.[a]		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
2	6	1.75 : 2.28 mm	.75 +	113°	3.16 + mm	2.87 + mm	1.10 +
1	7	2.00 : 2.50 mm	.80	116°	4.00 mm	3.00 mm	1.33 +
2	8	2.00 : 2.50 mm	.83 +	119°	4.00 mm	3.25 mm	1.26 +
1	9	2.50 : 3.00 mm	1.20	115°	4.50 mm	3.50 mm	1.28 +
2	10	3.00 : 2.50 mm	1.20	112°	4.50 mm	4.00 mm	1.12 +
1	11	3.00 : 2.75 mm	1.16 +	118°	5.00 mm	4.00 mm	1.25
2	12	3.40 : 3.40 mm	1.00	117°	5.50 mm	4.50 mm	1.22 +
5	13	3.25 : 2.70 mm	1.20 +	118°	5.25 mm	4.16 + mm	1.26 +
1	14	4.00 : 2.50 mm	1.60	113	5.33 mm	4.66 mm	1.14 +
1	15	6.00 : 4.00 mm	1.50	116°	7.50 mm	5.00 mm	1.50
1	16	5.50 : 3.00 mm	1.83 +	117°	6.00 mm	5.00 mm	1.20

[a] See preceding footnote.

BLOOMINGTON—HUNTER VALLEY—Continued.

Number of Specimens.	Number of Plural Pieces.	Relative Length of Ambulacral Area.*		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
3	18	5.66 + : 3.83 + mm	1.47 +	121°	7.66 + mm	5.83 + mm	1.31 +
1	19	5.50 : 4.00 mm	1.37 +	116°	7.00 mm	6.00 mm	1.16 +
2	20	5.75 : 3.25 mm	1.77 +	115°	7.00 mm	5.50 mm	1.27 +
1	22	7.50 : 4.00 mm	1.87 +	117°	9.00 mm	6.00 mm	1.23 +
1	23	7.00 : 3.50 mm	2.00	124°	8.00 mm	4.00 mm	2.00
1	24	7.00 : 3.50 mm	2.00	121°	8.50 mm	5.50 mm	1.54 +
1	25	8.00 : 4.00 mm	2.00	120°	9.50 mm	6.50 mm	1.46 +
1	26	8.00 : 4.00 mm	2.00	112°	8.00 mm	7.50 mm	1.06 +
1	27	8.00 : 4.00 mm	2.00	117°	10.50 mm	7.50 mm	1.40
1	33	10.50 : 5.50 mm	1.99 +	116°	12.00 mm	8.00 mm	1.50
1	34	11.00 : 5.50 mm	2.00	117°	14.50 mm	8.00 mm	1.81 +
1	35	11.00 : 5.50 mm	2.00	115°	14.00 mm	10.00 mm	1.40
2	40	16.50 : 8.50 mm	1.99 +	111°	16.50 mm	14.50 mm	1.13 +
1	43	15.00 : 7.00 mm	2.14 +	107°	15.50 mm	14.00 mm	1.10 +
1	45	15.00 : 6.00 mm	2.50	110°	15.00 mm	12.00 mm	1.25

ELLETTSVILLE—MATTHEWS' QUARRY.

1	13	3.33 : 3.33 mm	1.00	125°	5.33 mm	4.25 mm	1.25 +
1	15	4.33 : 3.33 mm	1.30 +	122°	6.33 mm	5.33 mm	1.18 +
1	16	4.66 : 3.33 mm	1.39 +	119°	6.50 mm	5.25 mm	1.23 +
1	19	5.50 : 3.50 mm	1.56 +	119°	7.20 mm	5.50 mm	1.30 +
1	22	6.00 : 3.50 mm	1.71 +	120°	8.00 mm	6.33 mm	1.26 +
2	25	7.75 : 3.75 mm	2.06 +	113°	9.00 mm	7.25 mm	1.23 +
2	26	9.08 : 4.50 mm	2.01 +	115°	10.50 mm	8.12 + mm	1.29 +
1	27	8.50 : 4.50 mm	1.88 +	117°	9.66 mm	7.50 mm	1.28 +
2	28	9.75 : 4.50 mm	2.16 +	115°	10.75 mm	7.44 + mm	1.44 +
1	29	9.50 : 4.25 mm	2.23 +	115°	11.00 mm	8.00 mm	1.37 +
2	31	9.25 : 4.50 mm	2.06 +	112°	10.16 + mm	8.00 mm	1.27 +
1	32	10.00 : 5.00 mm	2.00	108°	11.00 mm	9.50 mm	1.15 +
2	33	10.75 : 5.25 mm	2.04 +	107°	12.00 mm	9.50 mm	1.26 +
1	37	11.50 : 5.50 mm	2.09 +	101°	11.50 mm	9.50 mm	1.21 +
2	41	14.50 : 7.00 mm	2.07 +	108°	14.50 mm	11.92 mm	1.21 +

*See preceding footnote.

In studying the data the writer has gone carefully over each of the series of measurements and ascertained the number of specimens having a given measurement. The variates were then grouped into classes of convenient size and variation curves were plotted. This was done in order to get an idea of the ranges and modes of these different characters. The data from each locality were first considered in this way, and then the entire group of data, that is, the data for all the different localities were considered as a whole. The curves obtained in this manner give an idea of the developmental variations, but the element of specific variation also enters to a certain extent. In order to get a better idea of the specific variation another study of the data has been made. The data were considered by localities as before, but in this case there was a grouping of the specimens which were of approximately the same age. The number of poral pieces was taken as the criterion to determine the age. For instance, all specimens having from 8-12 poral pieces were considered in one group and all the different characters for this group were studied, and the ranges and modes of these characters were ascertained. This study was continued through the whole series, each group having a range of about 4 poral pieces. This grouping was done in order to eliminate the developmental element.

In Plates XLIII and XLIV are given the variation curves thus obtained from the Harrodsburg material. The curves on these plates give an idea of the general results of this study, therefore it is not thought necessary to take the space to give the curves for the other localities. However, the data which have been obtained from this study are given below. First are given the results of the study of the data for each locality, and the study of the data for all localities, showing the developmental variation; then the results of the study of the grouped data from Harrodsburg, Pentremite Hollow, and Spergen Hill, showing the specific variation.

	Poral Pieces.		Relative Length of Ambulacral Area.		Angle Between Ambulacral Area and Base.		Length.		Breadth.		Ratio of Length to Breadth.	
Number of Variates Included in Each Class.	3-4, 5-6, etc. Two in a Class.		.20-39, .40-59, etc. .20 in a Class.		95°-96°, 97°-98°. Two Degrees in a Class.		2-3, 3-4, etc. One Millimeter in a Class.		1-2, 2-3, etc. One Millimeter in a Class.		.30-39, .40-49, etc. .10 in a Class.	
Locality.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.
Harrodsburg. Number of specimens, 276.	3-34	7-8, 37 spec.	.33-2.14	1.00-1.19, 42 spec.	105°-128°	117°-118°, 73 spec.	2-13	5-6, 54 spec.	1⅝-8½	3-4, 4-5, 71 spec. in each.	1.00-1.71	1.20-1.29, 118 spec.
Pentremite Hollow. Number of specimens, 240.	8-63	35-36, 21 spec.	.80-3.08	2.00-2.19, 71 spec.	96°-125°	107°-108°, 38 spec.	4-22	7-8, 8-9, 10-11, 13-14, in first 3, 17 spec. each; in 4th, 18 spec.	3½-16	8-9, 32 spec.	.83-1.50	1.20-1.29, 82 spec.
Spergen Hill. Number of specimens, 112.	6-27	23-24, 14 spec.	.64-2.00	1.40-1.59, 31 spec.	102°-127°	107°-108°, 20 spec.	3⅓-9	7-8, 38 spec.	3-8	6-7, 39 spec.	1.00-1.45	1.00-1.19, 34 spec.
Stinesville. Number of specimens, 48.	5-33	7-8, 9 spec.	.55-2.28	1.00-1.19, 12 spec.	112°-124°	115°-116°, 12 spec.	3-12½	5-6, 12 spec.	2¼-9½	3-4, 16 spec.	1.08-1.46	1.20-1.39, 21 spec.
Hunter Valley. Number of specimens, 38.	6-45	18-19, 4 spec.	.64-2.50	2.00-2.19, 10 spec.	107°-124°	116°-117°, 10 spec.	3-18	5-6, 9 spec.	2¾-17	4-5, 12 spec.	1.00-2.00	1.20-1.29, 16 spec.
Ellettsville. Number of specimens, 21.	13-41	25-26, 4 spec.	1.00-2.23	2.00-2.19, 12 spec.	101°-125°	113°-114°, 4 spec.	5⅓-15	11-12, 6 spec.	4¼-12⅓	7-8, 6 spec.	1.13-1.56	1.20-1.29, 10 spec.
All localities. Number of specimens, 735.	3-63	13-14, 63 spec.	.33-3.08	2.00-2.19, 122 spec.	96°-128°	115°-116°, 114 spec.	2-22	5-6, 7-8, 99 and 100 spec.	1⅝-17	4-5, 118 spec.	.83-2.00	1.20-1.29, 281 spec.

HARRODSBURG.

	Relative Length of Ambulacral Area.		Angle Between Ambulacral Area and Base.		Length.		Breadth.		Ratio of Length to Breadth.	
Number of Variates in Each Class.	.20-.39, .40-.59, etc. .20 in a Class.		95°-96°, 97°-98°, etc. 2° in a Class.		2-3, 3-4, etc. One Millimeter in a Class.		1-2, 2-3, etc. One Millimeter in a Class.		.30-.39, .40-.49, etc. .10 in a Class.	
Classes Arranged According to Number of Poral Pieces.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.
3-7, 71 spec.	.33-.88	.60-.79, 30 spec.	105°-123°	111°-112°, 115°-116°, 12 spec. each.	2-4	3-4, 38 spec.	1⅝-3½	2-3, 48 spec.	1.00-1.40	1.10-1.19, 32 spec.
8-12, 77 spec.	.66-1.28	.80-.99, 1.00-1.19, 30 spec. each.	109°-127°	115°-116°, 117°-118°, 21 spec. each.	3¼-6	4-5, 48 spec.	2½-4⅓	3-4, 53 spec.	1.05-1.50	1.20-1.29, 38 spec.
13-16, 63 spec.	1.00-1.60	1.20-1.39, 27 spec.	112°-128°	115°-116°, 117°-118°, 17 spec. each.	4½-7	5-6, 36 spec.	3½-5½	4-5, 44 spec.	1.09-1.71	1.20-1.29, 36 spec.
17-20, 33 spec.	1.12-1.88	1.40-1.59, 13 spec.	112°-120°	117°-118°, 17 spec.	6-8	7-8, 15 spec.	4½-6	5-6, 24 spec.	1.09-1.45	1.30-1.39, 15 spec.
21-24, 20 spec.	1.41-2.00	1.60-1.79, 11 spec.	112°-122°	117°-118°, 7 spec.	7-9⅓	8-9, 9 spec.	5¼-7	6-7, 11 spec.	1.23-1.50	1.30-1.39, 10 spec.
25-34, 12 spec.	1.63-2.44	2.00-2.19, 7 spec.	108°-120°	117°-118°, 3 spec.	8½-13	9-10, 10-11, 3 spec. each.	6-8⅓	7-8, 5 spec.	1.33-1.62	1.30-1.39, 5 spec.

PENTREMITE HOLLOW.

	Relative Length of Ambulacral Area.		Angle Between Ambulacral Area and Base.		Length.		Breadth.		Ratio of Length to Breadth.	
Number of Variates in Each Class.	.20-.39, .40-.59, etc. .20 in a Class.		95°-96°, 97°-98°, etc. 2° in a Class.		2-3, 3-4, etc. One Millimeter in a Class.		1-2, 2-3, etc. One Millimeter in a Class		.30-.39, .40-.49, etc. .10 in a Class.	
Classes Arranged According to Number of Poral Pieces.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.
8-12, 8 spec.	.80-1.16	1.00-1.19, 5 spec.	112°-119°	113°-114° 3 spec.	4-5	5-6, 5 spec.	3½-4½	4-5, 7 spec.	1.00-1.25	1.10-1.19, 4 spec.
13-16, 8 spec.	1.00-1.50	1.20-1.39, 4 spec.	98°-119°	111°-112° 3 spec.	5-6½	5-6, 6-7, 4 spec. each.	4½-5	5-6, 5 spec.	.83-1.33	1.10-1.19, 1.20-1.29, 1.30-1.39, 2 spec. each.
17-20, 23 spec.	1.18-1.83	1.40-1.59, 12 spec.	106°-125°	113°-114° 5 spec.	6½-8	7-8, 15 spec.	5-7	6-7, 13 spec.	1.00-1.50	1.00-1.09, 8 spec.
21-24, 31 spec.	1.33-2.00	1.60-1.79, 12 spec.	103°-119°	115°-116° 6 spec.	7-9	8-9, 17 spec.	6-8	7-8, 16 spec.	1.05-1.33	1.20-1.29
25-28, 21 spec.	1.50-.214	1.80-1.99, 7 spec.	99°-117°	109°-110° 6 spec.	7½-11½	8-9, 8 spec.	6-10¼	8-9, 9 spec.	.92-1.41	1.20-1.29, 7 spec.
29-32, 33 spec.	1.20-2.37	2.00-2.19, 15 spec.	97°-114°	103°-104° 8 spec.	8-11½	9-10, 10-11, 13 spec each.	7-10	8-9, 14 spec.	.88-1.37	1.10-1.19, 18 spec.
33-36, 34 spec.	1.64-3.00	2.00-2.19, 19 spec.	98°-111°	105°-106° 8 spec.	10-14	11-12, 16 spec.	8-12½	9-10, 10-11, 11 spec. each.	.84-1.39	1.20-1.29, 14 spec.
37-40, 32 spec.	1.78-2.60	2.00-2.19, 17 spec.	102°-115°	107°-108° 9 spec.	12-15	12-13, 12 spec.	8-13	10-11, 11-12, 11 spec. each	1.08-1.50	1.20-1.29, 13 spec.
41-44, 20 spec.	1.87-2.66	2.00-2.19, 8 spec.	98°-111°	105°-106° 6 spec.	13-17	14-15, 11 spec.	9½-15	11-12, 7 spec.	1.00-1.37	1.20-1.29, 8 spec.

45-48, 13 spec.	2.12-2.66	2.20-2.39, 5 spec.	99°-112°	99°-100° 101°-102° 103°-104° 105°-106° 109°-110° 2 spec. each.	14-17	14-15, 16-17, 17-18, 4 spec. each.	10-14	11-11½ 5 spec.	1.16-1.47	1.20-1.29, 7 spec. 1.30-1.39, 5 spec.
49-52, 12 spec.	2.23-3.08	2.20-2.39, 5 spec.	96°-109°	105°-106° 4 spec.	15½-18½	18-18½, 6 spec.	11-14½	13 5 spec.	1.25-1.50	
56-63, 5 spec.	2.50-3.00	2.80-2.89, 2 spec.	97°-104°	103°-104° 2 spec.	15-22	15, 19, 20, 21, 22, 1 spec. each.	12-16	14-14½, 2 spec.	1.25-1.42	1.30-1.39, 1.40-1.49, 2 spec. each.

SPERGEN HILL.

6-7, 3 spec.	.64-.77	.60-.79, 3 spec.	112°-117°	111°-112°, 2 spec.	3⅓-3⅔	3-4, 3 spec.	3-3¼	3-4, 3 spec.	1.11-1.16	1.10-1.19, 3 spec.
8-12, 8 spec.	.85-1.20	1.00-1.19, 4 spec.	115°-121°	115°-116°, 3 spec.	3½-5½	5-6, 5 spec.	3-4½	3-4, 4-5, each, 4 spec.	1.16-1.42	1.20-1.29, 4 spec.
13-16, 19 spec.	1.00-1.66	1.00-1.19, 8 spec.	104°-124°	111°-112°, 117°-118°, 119°-120°, each, 3 spec.	5-7	5-6, 6-7, each, 9 spec.	3½-6	5-6, 10 spec.	1.05-1.42	1.30-1.39, 6 spec.
17-20, 32 spec.	1.25-1.71	1.40-1.59, 17 spec.	105°-127°	109°-110°, 6 spec.	5¾-8	6-7, 15 spec.	4½-7	5-6, 6-7, each, 14 spec.	1.00-1.45	1.10-1.19, 10 spec.
21-24, 42 spec.	1.37-2.00	1.60-1.79, 14 spec.	102°-121°	107°-108°, 12 spec.	6-9	7-8, 23 spec.	5¼-7½	6-7, 2. spec.	1.00-1.41	1.20-1.29, 14 spec.
25-27, 8 spec.	1.40-2.00	2.00-2.19, 4 spec.	102°-116°	105°-106°, 107°-108°, each, 2 spec.	7½-9	8-9, 5 spec.	6½-8	7-8, 6 spec.	1.03-1.28	1.10-1.19, 1.20-1.29, each, 3 spec.

Besides the specimens which have been used in obtaining the foregoing data, the writer has examined, as was stated before, almost 5,000 specimens. The smallest specimens which have been obtained were from the Harrodsburg (old Cleveland quarry) material. The distal ends of over a dozen of these small specimens have not been preserved. Five or 6 of the smallest of these (see Fig. 2) are about 0.82 mm. in length and 0.70 mm. in diameter. The bodies of these smallest specimens are conical. The distal

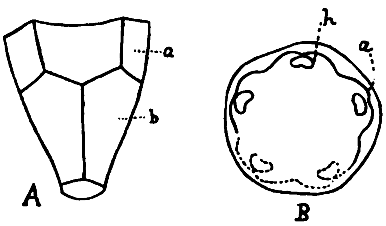


Fig. 2.

Fig. 2. A. Side view of one of the smallest specimens of *Pentremites conoideus*, (a) radials, (b) basals, x 25. B. View of the distal portion of the same specimen, (a) indention in the rim for the ambulacral area, (h) beginning of the hydrospire, x 25. Indiana University collection.

ends are circular and the body cavity is either empty or filled with calcareous matter. No structure can be made out with the unaided eye, but a microscopical examination shows that the body is composed of 8 pieces, 5 radials and 3 basals. Prof. G. Hambach* says that there are 5 basal pieces in the young, but that 2 of the 5 sutures become obliterated in the course of development. In all of the specimens which the writer has examined, she has been unable to find more than 3 basal pieces. In Plate XLVII (Figs. 5 and 6) 3 specimens are given which show the 3 basal pieces with the 3 sutures between. The smallest of the specimens shown in this figure is 1.29 mm. and the 2 larger ones are 1.88 mm. in diameter. The basals form almost two-thirds of the body. As seen from the side there is only a slight downward curve in the upper margins of the radials where the ambulacral areas are to be (see Fig. 2A and Plate XLV, Figs. 3, 4, 5). The same delicate striae which ornament the surface of the adut shell can be seen on the surface of these small specimens. Looking down on the distal

*Ibid., pp. 4-5.

portions of these specimens, the outer rims of the shells appear almost circular with a tendency to be slightly 5 cornered (see Fig. 2B and Plate XLV, Figs. 1 and 2). On the inner side of the rims the 5 ambulacral areas are becoming defined by 5 indentures. In the center of each of these indentations there is a small concave structure which is most probably the beginning of the hydrospire.

In all probability these smallest specimens represent the earliest stage in the development of *Pentremites conoideus*, which can be preserved in the fossil state. They have most likely just emerged from the free-swimming larval stage, grown a shell and assumed the sedentary mode of life. Since the Pentremites and the whole group of Blastoids are extinct this is as far back as we can go in tracing their development. However, we may speculate to some extent on their earlier development by a study of the embryology of the larger group to which they belong, namely, the Echinoderms. Korschelt and Hieder give an excellent presentation of this subject.* Of the living Echinoderms the crinoids probably most nearly resemble the Pentremites, for many of them were sedentary after the free-swimming stage was passed. In the crinoids (*Antedon*) the earliest skeletal pieces begin to form while the larva is still in its free-swimming stage. In the later free-swimming stage the tentacles project into a vestibule. The mouth also opens into this vestibule, "the roof of which is stretched out between the upper margins of the oralia. This roof is at first thick, but gradually becoming thinner finally disappears entirely. * * * After the disappearance of the roof of the vestibule, the tentacles * * * project free to the exterior. The underpart of the larva has elongated into the stalk, and it now rests with its terminal plate on some support. The fundaments of the arms bud forth on the upper part of the cup as five projections," etc.

The writer is of the opinion that these smallest Pentremites are at about the same stage in their development as has just been described for the crinoids. The arms of the crinoid are in part homologous to the ambulacral areas of the Pentremite. It is very probable that there was some such roof stretched between the upper margins of the radials in the young Pentremite as has just been described as being stretched out between the upper margins of the

*Korschelt and Heider, Textbook of the Embryology of Invertebrates, Part I, pp. 392-461.

oralia in the crinoid. If this is the case it would not be possible to find a Pentremite at this stage of development with the distal portion intact. The roof has probably just disappeared and the ambulacral areas are just beginning to be defined. The next step in the development is the formation of the ambulacral area, with its lancet piece, poral pieces, hydrospires, etc. As the poral pieces increase in number the ambulacral area grows down. The slight downward curve which is perceptible only with the aid of a microscope in these youngest specimens, gradually increases, until in the adult stage there is an incision or sinus almost the entire length of the radials. The poral pieces always grow at the tip or lower end of the ambulacral area. At the lower or growing end of this area the arrangement of the poral pieces is oblique and rather loose. Toward the top or older end of the ambulacral area the poral pieces are more crowded and have a horizontal arrangement. As the specimen grows the radials elongate, but the basals, which formed the greater part of the body in the youngest specimens, do not grow as rapidly, and in the adult they can not be seen in a side view. When the specimen has about 7 or 8 poral pieces the deltoids begin to show externally. These gradually increase in size as the specimen grows older.

With all these changes in structure, there must necessarily come changes in form. The young have relatively long, tapering bases and short ambulacral areas, while the old have relatively short, flat, or almost concave bases and long ambulacral areas; in other words, the relative length of the ambulacral area increases as the

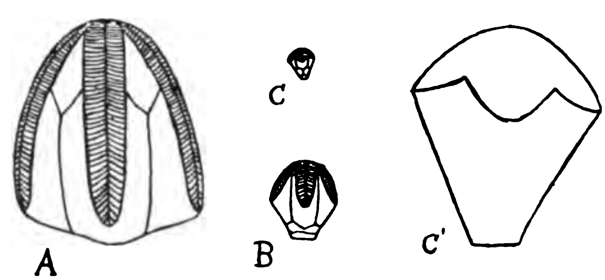


Fig. 3.

Fig. 3. A, B, and C. Large, medium, and small specimens showing the position of the angle between the ambulacral area and the base. x 2. C, enlarged outline of C. Indiana University collection.

specimen grows older. The angle between the ambulacral area and the base is, in general, smaller in the youngest and in the oldest stages and greater in the medium stages of growth. In the young, however, the angle is near the distal end of the body (see Fig. 3), in the old it is at the proximal end, while in the medium specimens it is near the middle. As the specimens grow older they also increase in length and breadth.

In a general survey of a series of specimens which show all these developmental changes (see Plate XLVI), another thing is quite noticeable, namely, the change from the angular to the curved contour of the whole body. As the ambulacral areas grow in length, and the basal pieces do not keep pace with them, there must necessarily be a curving of these areas. In the oldest or most gerontic specimens there is also a tendency for the base to curve downward at the end of each ambulacral area.

Another interesting point has been the comparison of the young of *P. conoideus* with *Codaster sp.* from the Hamilton formation at Thedford, Ontario. The shape of the young Pentromite is almost identical with the shape of the Codaster (see Plate XLVII, Fig. 1.) Each have the long, tapering base and the short ambulacral area. The arrangement of the poral pieces is also quite similar. The young Pentremites have a loose and oblique arrangement of the poral pieces, as have also the Codasters. This similarity between the two would seem to indicate a rather close relationship and gives at least a hint as to the possible ancestry of Pentremites. Codaster may be the ancestor of Pentremites, or Codaster and Pentremites may have descended from a common ancestor.

In examining the 4,400 specimens from Mr. G. K. Greene's collection, the writer has discovered 5 small plates or septa in the oral opening of *Pentremites conoideus*. Three specimens show this structure in an excellent state of preservation; a dozen or more contain all these plates intact, but the preservation is not so good; while a great many others show fragments of them. Altogether there was found about 130 specimens which show all or a part of this structure. The outer end of each plate or septum is attached, in every instance, to the distal end of a lancet piece, that is, to the center of the distal end of an ambulacral area. Each of these 5 plates projects inward toward the center of the mouth opening where they unite. This was the case with the

structure in the 3 best preserved specimens. In some of the others, 2 of the plates seemed to unite before reaching the center of the mouth opening. This, however, may be due to the state of preservation of the structure. The oral opening is thus divided by these plates or septa into 5 small triangular openings. These plates appear to be rather thin and flat, and are arranged so that they stand with the thin edge up. In a great many, perhaps in most cases, this structure is set well down in the oral opening; in other cases it is nearer the top of the opening. The place of attachment of the outer ends of these plates, and their general arrangement, are, however, most constant characters. In every specimen which was found to contain all or a part of these plates intact, the attachment was as described above.

It is difficult to say just what the function of these plates was, but some suggestions might be offered. It is possible that they acted as a sort of strainer which prevented particles of food of too large size from entering through the mouth opening. It is also possible that they served as places of attachment for muscles which controlled the tentacles or perhaps some jaw-like structure. Or, again, it is possible that they had a sort of hinge movement of their own which enabled them to open and close these 5 small openings.

In regard to the genital openings, it is the writer's opinion that there was also some kind of a structure in them, but no specimen has been found in which this structure is well enough preserved to ascertain just what it was.

The regularity of the place of attachment of the plates in the oral opening seems to preclude any doubt of the genuineness of this structure. Prof. G. Hambach* denies in a very decisive manner the existence of any plates in the mouth or genital openings. One of his arguments against the existence of these plates is the difference in the descriptions and illustrations of the different authors. This difference is probably due, for the most part, to the difference in the preservation of the structures in their respective specimens. This structure, being a very delicate one, is seldom preserved in good condition, and these authors probably based their descriptions upon only 1 or 2 specimens; at least this was

*Ibid., pp. 15-16.

the case with Shumard. Then, again, some of this difference in descriptions may be due to the individuality of the author. As to Prof. Hambach's idea, that the plates are only little scales or particles of broken pinnulae which have dropped into the summit openings, it is hardly possible that they would always drop into the openings in such a systematic manner as has been described above. And, again, Prof. Hambach says, "It stands to reason, and is only logical to suppose, that if nature provided an opening it should remain open," etc., but he seems to lose sight of this logic, when, in the same paragraph he speaks of "*Olivanites* and others where the center of the summit is closed."

It will be understood, of course, from the description given above, that the present writer does not maintain that the oral opening was entirely closed, as was described and figured by Shumard*, but it is certainly a fact that there were 5 plates or septa in this opening which divide it into 5 smaller openings.

DWARFING OF THE FAUNA OF THE SALEM LIMESTONE.

The studies of the development and variation of *Pentremites conoideus* have led incidentally to a consideration of another point, namely, the dwarfing of the fauna of the Salem Limestone. The fossils from the old Cleveland quarry near Harrodsburg, from which place 276 specimens of my series come, are dwarfed forms quite typical of this formation. The fossils from Pentremite Hollow, near Bloomington (upper part of the Harrodsburg limestone) are normally developed. Two hundred and forty specimens of the above series come from this latter locality. A comparison of the specimens from these 2 localities is interesting.

The data given above in the variation study shows that there are 71 specimens from Harrodsburg which are smaller and which have a smaller number of poral pieces than any specimen from Pentremite Hollow, and that there are 103 specimens from Pentremite Hollow which are larger and which have a greater number of poral pieces than any specimen from Harrodsburg. But there are specimens from both localities having the same number of poral pieces. The number of poral pieces in these specimens ranges from 8 to 34. The measurements of specimens having the

*Trans. Acad. Sci. of St. Louis, Vol. I, pp. 243-244, Plate ix, Fig. 4.

same number of poral pieces are averaged. This is done for specimens from both localities. The data thus obtained have been tabulated as follows:

HARRODSBURG AND PENTREMITE HOLLOW SPECIMENS COMPARED.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.*		Angle Betw. en Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
H. 16	8	2.04 + : 2.43 + mm	.83+	116°	3.75 mm	3.25 mm	1.15+
P. H. 1	8	2.00 : 2.50 mm	.80	112°	4.00 mm	3.50 mm	1.14
H. 18	10	2.51 + : 2.78 + mm	.90+	118°	4.46 + mm	3.58 + mm	1.24+
P. H. 1	10	2.50 : 3.00 mm	.83+	114°	4.00 mm	4.00 mm	1.00
H. 16	11	2.76 + : 2.68 + mm	1.02	117°	4.62 + mm	3.78 + mm	1.22+
P. H. 2	11	2.75 : 3.00 mm	.91+	117°	4.75 mm	4.00 mm	1.18+
H. 15	12	3.00 + : 2.76 + mm	1.08+	118°	4.96 + mm	3.95 + mm	1.23+
P. H. 4	12	3.18 : 3.06 + mm	1.03+	115°	5.00 mm	4.25 mm	1.17+
H. 13	13	3.38 + : 2.91 + mm	1.16+	118°	5.32 + mm	4.18 + mm	1.27+
P. H. 3	13	3.36 + : 3.00 mm	1.12+	115°	5.44 + mm	4.72 mm	1.15+
H. 15	15	3.81 + : 2.93 + mm	1.30+	115°	5.71 + mm	4.56 + mm	1.25+
P. H. 4	15	4.25 : 3.25 mm	1.30+	113°	6.00 mm	5.00 mm	1.20
H. 16	16	4.34 + : 3.32 mm	1.30+	117°	6.15 + mm	4.84 mm	1.27+
P. H. 1	16	4.50 : 3.50 mm	1.28	95°	5.00 mm	6.00 mm	.83
H. 9	17	4.66 : 3.17 + mm	1.47	116°	6.38 + mm	5.11 mm	1.24+
P. H. 4	17	5.25 : 3.91 + mm	1.34+	113°	6.81 + mm	5.79 mm	1.17+
H. 5	18	4.60 : 3.17 mm	1.45+	119°	6.45 mm	5.05 mm	1.27+
P. H. 5	18	5.10 : 3.35 mm	1.52+	115°	6.93 mm	5.80 mm	1.19+
H. 8	19	5.14 : 3.31 + mm	1.55+	116°	6.87 + mm	5.34 + mm	1.28+
P. H. 8	19	5.59 + : 3.65 + mm	1.53+	110°	6.87 + mm	6.03 + mm	1.13+
H. 10	20	5.60 : 3.55 mm	1.57+	116°	7.37 + mm	5.54 + mm	1.33+
P. H. 6	20	5.86 : 3.83 + mm	1.53+	111°	7.30 + mm	6.30 + mm	1.15+
H. 5	21	5.76 + : 3.36 + mm	1.71+	115°	7.23 + mm	5.55 mm	1.39+
P. H. 8	21	6.25 : 3.84 + mm	1.63+	110°	7.58 + mm	5.81 + mm	1.30+
H. 9	22	6.20 + : 3.66 + mm	1.69+	116°	8.25 + mm	6.11 mm	1.35+
P. H. 7	22	6.73 + : 4.07 + mm	1.65+	112°	8.02 + mm	7.04 + mm	1.13+
H. 3	23	6.75 : 3.66 + mm	1.84+	113°	8.22 mm	6.50 mm	1.26+
P. H. 10	23	6.92 + : 4.12 + mm	1.67+	111°	8.01 + mm	6.92 mm	1.30+
H. 3	24	7.11 : 4.16 + mm	1.73+	119°	9.28 mm	6.83 + mm	1.35+
P. H. 6	24	7.20 + : 3.91 + mm	1.81+	108°	8.52 + mm	7.16 + mm	1.18+
H. 4	25	7.25 : 3.81 + mm	1.90+	115°	8.87 + mm	6.41 + mm	1.38+
P. H. 4	25	7.12 : 4.00 mm	1.78	109°	8.25 mm	7.00 mm	1.17+
H. 1	26	8.00 : 4.50 mm	1.77+	120°	10.50 mm	7.50 mm	1.40
P. H. 8	26	8.31 + : 4.56 + mm	1.82+	109°	9.27 mm	7.93 + mm	1.16+
H. 3	28	8.00 : 4.00 mm	2.00	113°	9.66 + mm	7.00 mm	1.38
P. H. 4	28	8.66 + : 4.75 mm	1.82+	103°	9.87 + mm	8.50 mm	1.16+
H. 2	29	9.50 : 4.50 mm	2.11+	113°	12.00 mm	7.50 mm	1.60
P. H. 6	29	8.52 + : 4.75 mm	1.79+	109°	9.66 + mm	8.00 mm	1.20+
H. 1	31	10.50 : 5.00 mm	2.10+	110°	12.00 mm	8.00 mm	1.50
P. H. 7	31	9.61 : 5.00 mm	1.92+	104°	10.25 mm	9.03 + mm	1.13+
H. 1	34	11.00 : 4.50 mm	2.44+	108°	11.50 mm	8.50 mm	1.35+
P. H. 5	34	10.60 : 5.50 mm	1.92+	106°	11.50 mm	9.80 mm	1.17+

*The ratio of the numbers in the first two columns is given in the third column.

A study of the data shows that there are 21 sets of comparisons.

In the comparison of the absolute length of the ambulacral area it was found that in 13 out of the 21 comparisons the absolute length of the ambulacral area in the Harrodsburg specimens was less than in the Pentremite Hollow specimens. The average length of the ambulacral area in the Harrodsburg specimens which were compared was 5.80+, and in the Pentremite Hollow specimens it was 5.91+.

The absolute length of the base was found to be less in the Harrodsburg specimens in 19 of these comparisons, and in 1 comparison it was the same in specimens from both localities. The average for all comparisons was, Harrodsburg 3.57+, Pentremite Hollow 3.83+.

The relative length of the ambulacral area was found to be greater in the Harrodsburg specimens than in those from Pentremite Hollow in 17 of these comparisons. In 1 comparison it was the same for specimens from both localities. The average for all comparisons was, Harrodsburg 1.62+, Pentremite Hollow 1.54+.

The angle between the ambulacral area and the radius of the base was greater in Harrodsburg specimens than in specimens from Pentremite Hollow in 20 of these comparisons. In one comparison this angle was the same for specimens from both localities. The average for all comparisons was Harrodsburg 115°, Pentremite Hollow 110°.

The length was greater in the Harrodsburg specimens than in those from Pentremite Hollow in 10 comparisons. In 2 comparisons it was the same for specimens from both localities. The average for all comparisons was Harrodsburg 7.59+, Pentremite Hollow 7.28+.

The breadth was less in the Harrodsburg specimens than in those from Pentremite Hollow in all comparisons. The average for all comparisons was Harrodsburg 5.67+, Pentremite Hollow 6.40+.

The ratio of length to breadth was greater in Harrodsburg specimens than in those from Pentremite Hollow in 20 of these comparisons. In one comparison it was greater in Pentremite Hollow specimens. The average for all comparisons was Harrodsburg 1.33+, Pentremite Hollow 1.15+.

The conclusions which the writer reaches from the data are, first, that the Harrodsburg specimens did not live to be as old as the Pentremite Hollow specimens; second, that there was more of a tendency to crowd the poral pieces into less space in Harrodsburg specimens than in Pentremite Hollow specimens; third, relatively longer ambulacral areas in Harrodsburg specimens means relatively more poral pieces in Harrodsburg than in Pentremite Hollow specimens; fourth, greater angle, greater average length and less breadth in Harrodsburg than in Pentremite Hollow specimens shows that the Harrodsburg specimens were less robust than those from Pentremite Hollow.

In order to learn something as to the possible cause of this dwarfing the writer has reviewed Semper's "Animal Life," Davenport's "Experimental Morphology," and an article "On the Correlation Between Growth and Food Supply in Starfish," by A. D. Mead [Amer. Nat. 1900, pp. 17-23]. Below is given a brief resumé of the conclusions of these authors.

Mead considered only the food supply as a cause of dwarfing. He concluded that insufficient food alone would cause dwarfing in the starfish.

Semper also mentions insufficient food as a cause of dwarfing. Quality of food is also considered, but he concluded that the organs of digestion were affected more by this than the whole size of the animal. Too low or too variable temperature is also a cause of dwarfing, but the variable temperature is more detrimental to growth than a constant low temperature. Variation in the amount of salt in the water will sometimes hinder the growth of animals.

Davenport agrees with Semper that animals in a small body of water are smaller than animals in a large body of water. Davenport also concluded that increasing the number of individuals in a vessel has the same effect as diminishing the volume of water. In considering the effect of the density of a solution, Davenport concluded that to increase this density beyond the normal would cause the rate of growth of animals living in it to be diminished. He also concluded that diminished oxygen retards growth.

Another point which was discussed by Semper is an explanation regarding the rich variety of the fauna in the Mediterranean and

the Red Seas. His explanation for this richness of forms is not the greater saltness, as is claimed by some, but that the superficial currents carry swimming creatures and the larvæ of non-migratory animals into these seas through the narrow straits and that many more creatures are brought in than are carried out.

Let us now consider the possible cause of the dwarfing of the fauna of the Salem Limestone. We know from the foregoing study that the conditions in the sea in which the Harrodsburg specimens lived must not have been favorable to longevity or to robust growth. It is difficult to say just what these unfavorable conditions were, but, in the light of the foregoing statements let us see what conclusions we can draw in regard to them. We know that the sea must have been teeming with life, for the Salem limestone is very rich in fossils. We might explain this richness of the fauna in the same way as Semper explains the rich variety of forms in the Mediterranean and Red Seas, namely, because the currents carried more creatures in than were carried out. There may have been coral-reefs not very far out from the shore-line which partially enclosed that portion of the sea in which the Salem limestone was laid down. Judging from the cross-bedding which quite frequently occurs in this limestone it is very probable that there were currents and that the sea was shallow. It is also probable that the shore was low and perhaps almost swampy, because the limestone is free from sediment which would have been carried into the sea had the adjacent land been high. The conditions along this ancient shore-line must have been similar to those which now exist along the southern Florida coast, and as far as the clearness and depth of the water was concerned it must have been favorable to the growth of coral reefs. If there were currents, there must also have been a sufficient food supply. It is quite probable, therefore, that the coral reefs existed. The Salem limestone was probably laid down in a lagoon or partially enclosed sea, and the dwarfing of the fauna was perhaps due, in part, to the smallness of the body of water and to an overcrowding. According to Semper and Davenport this in itself would cause dwarfing. There is another point, however, which has been brought out by the above comparison of the dwarfed and normal forms, which

might give us a hint as to another cause, namely, the slight tendency for the Harrodsburg specimens to have relatively longer ambulacral areas and hence relatively more poral pieces than the Pentremite Hollow specimens. Since the poral pieces are connected with the hydrospires, which are regarded as the respiratory organs of Pentremites, their increased number would indicate an effort of the animal to adapt itself to a depletion of oxygen in this ancient sea.

ECHINODERMA.

BY J. W. BEEDE.

BATOCRINUS ICOSIDACTYLUS Casseday.

Plate XII, figs. 6-6b.

Batocrinus icosidactylus Casseday, Zeitschrift d. Deutsch. Geol. Gesellsch., VI, p. 238, pl. II, ff. 1, 1a-c, 1854.

Wachsmuth and Springer's description: "Calyx nearly as wide as high. Dorsal cup rarely more than half the height of the ventral disk, low saucer-shaped, with a protuberant base; plates heavy, slightly convex, their surface smooth or obscurely granular.

"Basal cup projecting conspicuously beyond the level of surrounding plates, almost circular in outline; the median part deeply depressed for the reception of the column; central perforation subpentangular. Radials short, partly hidden from view by the overhanging rim of the basals. First costals quadrangular, three times as wide as long, narrower than the second. Distichals two, a little larger than the costals. Palmers three, increasing in width upward and placed in longitudinal series, which are separated by well defined grooves. Arm openings facing laterally, forming a continuous row around the calyx. Arms four to each ray; their structure not known. Interbrachials three (rarely four) to the interradius; the first much larger than the other two. The anal plate, which resembles the radials, is followed by three plates, and these by one or two. Interbrachials not connected with the plates of the tegmen, the higher brachials being in lateral contact. Ventral disk conical, passing gradually into a strong, almost central tube. The larger plates, as a rule, are extended into thorn-like projections, and are surrounded by smaller, slightly convex pieces. Orals quite excentric, four of them spinous, the posterior one merely convex. The radial dome plates, which are represented by plates of a first, second and third order, are also spiniferous. Anal tube long, heavy, and composed of convex pieces, among which larger thorn-like plates are scattered at intervals. Column round."

Localities: Lanesville, Paynters Hill, Spergen Hill.

BATOCRINUS IRREGULARIS Casseday.

Plate XII, figs. 1-1a.

Batocrinus irregularis Casseday, Zeitschr. d. Deutsch. Geol. Gesellsch., Vi, p. 240, pl. II, ff. 2a-c, 1854.

"Resembling the preceding species, but readily distinguished by its smaller size, more elongate form, much greater depth of the dorsal cup, by having a less number of arms, and the absence of spiniferous plates in the tegmen. Surface of plates smooth or slightly wrinkled, the radial ones transversely ridged; suture lines distinct.

"Basal cup projecting, circular in outline, deeply excavated for the attachment of the column. Radials short, considerably wider than the costals. Costals small, quadrangular, twice as wide as long; succeeded in four of the rays by 2x2 distichals, which resemble the costals in form and size, and support 2x2x2 fixed palmers. In the anterior ray there are two rows of three successive distichals followed by the free arms. Arms eighteen, the ambulachral openings directed horizontally. Interambulachral plates three; the first larger, supporting two plates in the second range. The anal piece is succeeded by three plates, and one above. Tegmen high-conical, higher than the dorsal cup; composed of comparatively few, large, tumid plates. Anal tube stout, almost central; constructed of strongly nodose pieces. Arms and column unknown."

Localities.—Lanesville, Paynters Hill, Spergen Hill.

BATOCRINUS MAGNIROSTRIS Rowley.

Plate XV, figs. 1-3.

Batocrinus magnirostris Rowley, Cont. Ind. Pal., I, pt. XVII, p. 170, pl. LI, ff. 1-3, 1904.

"In this species the ventral disk is deeper than the dorsal cup and the base of the ventral tube is very strong. The calyx rapidly expands from the basal plates and forms a low cone. The three basal plates form a distinct rim. The columnar canal is round. The ornamentation of the plates of the dorsal cup consists of fine, radial lines and low radiating ridges. The final radial is broader than long and has a slight cross ridge. The second radial is quad-

rangular, broader than long, and has a low cross ridge. The third radial is pentagonal, broader than long, and has a cross ridge as in the first and second plates. There is another bifurcation above the third primary radial. A slender thread-like line traverses the radial series from the base to the arms. The first interradial plate sends off indistinct radiating ridges from the center. Above this latter plate are one or two smaller plates. There are eighteen arm bases, four to the ray, except the one opposite to the anal area, which has but two. To each group there are always two large respiratory pores, or ten in all. The plates of the ventral disk are strongly nodose and the nodes are sharp. The ornamentation of the dorsal cup reminds one of delicate ripples. The proboscis (ventral tube) is stout, long and nodose. The plates are rather thick." (Rowley.)

Locality: Lanesville.

I have seen no authentic examples of this species.

BATOCRINUS SALEMENSIS Miller and Gurley.

Plate XII, figs. 2-2b.

Batocrinus salemensis Miller and Gurley, Bull. No. 9, Ill. State Mus. Nat. Hist., p. 8, pl. I, ff. 10-12, 1896.

"Species small, vault and calyx subequal, depressed, biturbinate. Calyx saucer-shaped, between one and three times as wide as high. Plates convex, radial series somewhat angular. Ambulachral openings directed horizontally.

"Basal plates form an hexagonal disc one-half wider than the diameter of the column and having a height equal to about one-fourth the diameter of the column. The depression for the attachment of the column is hemispherical. The first primary radials are between two and three times as wide as long, three hexagonal, two heptagonal. Second primary radials quadrangular, short, from three to five times as wide as long. Third primary radials only a litttle larger than the second, from three to four times as wide as long, pentagonal, axillary, and, in four of the rays, bear upon each upper sloping side two secondary radials, the last ones of which are axillary, and bear upon the upper sloping side two tertiary, which gives to each of these rays four arms. In the ray opposite the azygous area, the third pri-

mary radial bears upon each upper sloping side three secondary radials, which gives to it two arms. There are, therefore, eighteen arms in this species, and eighteen ambulachral openings to the vault.

"In each of two of the interradial areas there are three plates, one large followed by two small plates. In each of the other two areas there are only two plates, one large plate followed by one plate in the second range. In the azygous area there are six plates. The first one is in line with the first primary radials and nearly as large, it is followed in the second range by three plates, above which there are two plates. One is above the middle plate and one is to the right of it.

"The vault is moderately convex, covered with polygonal spinous plates, and bears a subcentral proboscis. No ovarian pores have been discovered.

"This species is distinguished among the eighteen armed species, by its general form, surface ornamentation, two secondary radials, and by the interradial azygous areas.

"It was found in the Warsaw group, at Salem, Indiana, and is now in the collection of Charles L. Faber."

BATOCRINUS SACCULUS Miller and Gurley.

Plate XII, figs. 7-7b.

Batocrinus sacculus Miller and Gurley, Bull. 5, Ill. State Mus. Nat. Hist., p. 52, pl. V, ff. 7-9, 1894.

"Body of medium size. Calyx somewhat saucer-shaped, three times as wide as high; arms directed horizontally; plates convex, sutures distinct; surface granular. Our specimen is a little depressed below, so as to produce an unnatural concavity around the column, and, therefore, does not show the full height of the calyx; it appears to be four times as wide as high, but remove the depression and it will not be more than three times as wide as high. The column is round, and plates rather thick and beveled toward the sutures so as to make them sharply angular in the middle.

"Basals small, low, and extending only a little beyond the column. The first radials small, one-half wider than high. Second radials two-thirds as large as the first, quadrangular and only a little wider than long. Third radials very little larger than the

second, four pentagonal, the one opposite the azygous area heptagonal, axillary and bear upon each upper sloping side a tertiary radial. In the ray opposite the azygous area the second secondary radials are rather large and bear the free arms. This gives to the species eighteen arms. The arms are small and directed horizontally.

"There are three plates in each regular interradial area, the first are the larger plates of the calyx, and each is followed by two rather long plates. In one or two of the areas there is a small plate above these. The first azygous plate is a little larger than the first radials and it is followed by four plates in the second series; above these the sutures are obscure in our specimens, but apparently there are three in the third series and above these there is one or two plates that connect with the plates of the vault.

"The vault is convex, most ventricose on the side opposite the azygous area. It is fully as large as the calyx and bears a very small subcentral proboscis. It is covered with rather large, polygonal, convex plates, and is slightly depressed in the interradial areas.

"This species somewhat resembles in form *B. spergenensis,* but differs in the interradial and azygous areas, beside that is a twenty-armed species while this has only eighteen. It will not be mistaken for any hitherto described.

"Found in the Warsaw group, in Washington County, Indiana, and now in the collection of Wm. F. E. Gurley."

BATOCRINUS CALYCULUS Hall.

Plate XIV, figs. 3-3b.

Actinocrinus calyculus Hall, Supp. vol. I, pt. II, Geol. Rep. Ia., p. 55, pl. I, ff. 12a-c, 1860.

"Body depressed turbinate below the arms and abruptly conical above, probosics a little excentric on the anal side; base rounded, plates short, with the lower margins forming a projecting rim, within which is a shallow symmetrical depression for the reception of the column; the edges of the plates a little elevated on each side of the suture line. Radial plates short, the second often not fully developed; the third radial supporting two series of secondaries or supraradials, of which the lower ones are quadrangular and the

upper ones larger and pentagonal, each one of the latter supporting two brachial plates, and these each an arm plate in direct succession, giving origin to four arms to each ray except the anterior ray, where there are but two arms, the secondaries in direct line to the arm plates. First interradial plate 10 or 11 sided; second interradial small or often not developed. First anal plate large, wider than long; second anal plates, three, of which the central one is larger than the first radial, and supports in part the brachial plates of the adjacent rays. Dome abruptly conical, composed of small acutely spiniferous plates. Proboscis undetermined. Surface of plates marked by short undulating or subgranulose ridges, which have the general character of radiating from the center of the plates. This small species differs from any other in this rock, and, though approaching some of the forms in the Burlington limestone, is nevertheless quite distinct."

Locality: Spergen Hill.

BATOCRINUS DAVISI Rowley.

Plate XV, figs. 7, 8, 9.

Batocrinus davisi Rowley, Cont. Ind. Pal., I, p. 171, pl. 51, ff. 7-9, 1904.

"This is another 18-armed form, with convex calix plates, the latter ornamented by short, irregular raised lines and pits of a most delicate character. A slight raised line connects the radial plates.

"The radials are wider than long, and there are two bifurcations to the ray in four radial rays.

"The first interradial is larger and supports two smaller plates above.

"The basal plates form a rim. The column is rather large and the perforation round.

"The ventral disk is as deep as the dorsal cup, and the plates are nodose-spinose.

"The anal tube is central and strong and probably nodose.

"The first plate of the anal interradius supports three plates above, and above them are three others.

"Horizon, locality and collection same as last (Lanesville).

"This specimen was originally described from the Kaskaskian limestone."

BATOCRINUS CRASSITESTUS Rowley.

Plate XV, figs. 10, 11, 12.

Batocrinus crassitestus Rowley, Cont. Ind. Pal., I, p. 172, pl. 51, ff. 10-12, 1904.

"This crinoid is subglobose, with a deeper ventral disk than dorsal cup.

"The broad plates form a distinct rim and, as in the preceding forms, the radial plates are convex and wider than long and slightly connected by a low line. There are two bifurcations to the ray except in the anterior ray.

"The large first interradial plate is 9 or 10 sided, convex, with indistinct lines radiating from its center. Above it are one or two smaller convex plates.

"The first anal interradial is twice as wide as long, and supports three larger convex plates above. Upon these three plates rest two other plates of nearly equal size. A small plate lies above these two.

"There are eighteen arm bases in five groups, with two respiratory pores to the group, or ten in all.

"The plates of the ventral disk are strongly nodose, almost spinose, but with no definite arrangement to the nodes.

"The proboscis or ventral tube is subcentral and very strong, also nodose. The body plates are all thick." (Rowley.)

Locality: Lanesville.

BATOCRINUS DAVISI LANESVILLENSIS (Rowley).

Plate XV, figs. 13, 14, 15.

Batocrinus davisi var. lanesvillensis Rowley, Cont. Ind. Pal., I, p. 172, pl. 51, ff. 13-15, 1904.

"In this crinoid the depth of the dorsal cup and the ventral disk are about the same.

"The basal plates form a slight rim. The stem is rather large and the perforation large.

"All of the radial plates are somewhat wider than long, a very little convex and all connecting by a single line.

"The first interradial plate is the largest plate on the dorsal cup and about as long as wide, a little convex, with the slightest ap-

pearance of raditaing ridges. Above this plate are two smaller ones, and two yet smaller above the latter two.

"There are nineteen arm bases with 2 pairs of respiratory pores for each group, or twenty in all.

"The arm groups are somewhat grouped in this form, unlike the previously described forms.

"The plates of the ventral disk are convex and each with a small nipple-like spine.

"The anal tube is only moderately strong, and with convex plates bearing central nodes.

"The first plate of the anal area is a little longer than the first radial plate, and supports above three rather large plates. Above these latter appear to be two smaller plates." (Rowley.)

Locality: Lanesville.

BATOCRINUS DAVISI, SCULPTUS (Rowley).

Plate XV, figs. 22, 23.

Batocrinus davisi var. Sculptus Rowley, Cont. Ind. Pal., I, p. 174, pl. 51, ff. 22, 23, 1904.

"The dorsal and ventral cups are of equal depth.

"The column rather large and the basal plates forming a low rim.

"All of the calyx plates are a little convex with fine radiate-line sculpture, a delicate ridge traversing the radial plates. The fine radiating ridges are often broken up and on some plates display no definite arrangement, crossing some of the radial plates entirely.

"The radial plates are wider than long and the radial series embraces three orders of plates.

"The interradial series contains four plates, 1, 2, 1, the lower one being the largest plate in the dorsal cup.

"The anal area has eight plates, 1, 3, 3, 1.

"The plates of the ventral disk are smooth and convex, some of them having a low, nipple-like central node.

"The anal tube is not very strong and located near the center.

"There are eighteen arm bases, the anterior ray having but two.

"The ornamentation of the dorsal cup of this form will readily distinguish it." (Rowley.)

Locality: Lanesville.

DIZYGOCRINUS WHITEI Wachsmuth and Springer.

Plate XII, figs. 4-4a.

Batocrinus whitei Wachsmuth and Springer, Proc. Acad. Nat. Sci. Phil., p. 343 (Rev. Palaecr.), 1881.

"Calyx small, depressed globose; dorsal cup equal to, or but little higher than, the ventral disk; the arm regions slightly projecting. Surface of plates ornamented. The radials and brachials have along their medial lines a well defined ridge, and at each side of this ridge, toward the sides of the plares, an annular node, which appears in the specimens as forming an independent plate. Ridges or rows of small tubercles occur also on the interbrachials, some of them proceeding from the center of the first plate to the radials, others to the higher interbrachials.

"Basals short, forming a projecting circular rim, with a shallow striated depression for the reception of the column. Radials twice as wide as long; the sloping upper sides shorter than the corresponding lower ones. Costals considerably shorter and narrower than the radials; the first quadrangular, and the second pentangular. Distichals 2x2, of similar form, but smaller than the costals; in the anterior ray supporting the arms; in the other rays followed by 2 rows of palmers. The upper faces of all arm-bearing plates are directed outward and formed into circular, rather large facets with a notch at the upper end. The surface of these facets is slightly concave and grooved at the inner margin. Arms 18, single, infolding, gradually tapering, and constructed from the second free plate of 2 series of moderately long pieces. Pinnules very long, composed of joints 3 times longer than wide. Interbrachials: 1, 2, 1, sometimes with an additional narrow piece between the arms. Anal plate somewhat higher than the radials, and followed variously by 3, 3 and 2 plates or by 3, 2, 1 and 1; the latter being generally the case in specimens from the Keokuk group, the former in those from the Warsaw limestone. Plates of the ventral disk of nearly equal size, all covered with a sharp central tubercle. Anal tube long, extending beyond the tips of the arms, constructed of convex plates interspersed with slightly nodose or spinous pieces. Column slender; composed of large and smaller joints, the larger ones with convex edges."

Localities: Lanesville ?, Paynters Hill ? and Spergen Hill.

"Miller's *Batocrinus spergenensis* was described from a specimen of *Dizygocrinus whitei* from which the surface markings were eliminated by weathering." (W. & S.)

There are young crinoids occurring at Paynters Hill and Spergen Hill which in all probability belong to this species, *D. euconus* and others but which can not be referred to any species with certainty. Some of these are figured, others are omitted, though they are good specimens. Wachsmuth and Springer remark some of these crinoids occurring in the Warsaw have more plates than those of the Keokuk and Burlington. As would be expected, the young specimens of the Salem limestone have fewer anal and interradial plates than the adults. Not infrequently these tiny plates may be discovered with the lens just making their appearance.

DIZYGOCRINUS EUCONUS Meek and Worthen.

Plate XII, fig. 3; Plate XVI, figs. 2-2a.

Actinocrinus (Alloprosallocrinus) euconus Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 164, 1865.

Wachsmuth and Springer's description: "In general form resembling *Alloprosallocrinus*. Dorsal cup very slightly convex, the sides spreading abruptly from the top of the basals to the arms. Base small, projecting, circular in outline, with shallow depression for the reception of the column. Surface of plates smooth, without ridges or other elevations. Suture lines indistinct. Radials hexagonal, about twice as wide as high. First costals quadrangular, smaller than the second. Distichals 2, followed in the anterolateral rays by 2 rows of palmers, and 4 single arms; while the anterior ray, which has an additional distichal at each side, and no palmers, has 2 arms. The posterior rays have palmers in the division next to the anal side and 3 arms, there being 16 arms in the species. Structure of the arms unknown. Interradials 3 at the regular sides and 6 above the anal plate, the upper row at all sides arched by the armbearing brachials. Ventral disk regularly conical, twice as high as the dorsal cup, composed of rather large, convex pieces; the posterior oral erect and forming the base of the anal tube. The tube is stout at the base and nearly central."

Locality: Spergen Hill.

DIZYGOCRINUS UNIONENSIS Worthen.

Plate XVI, figs. 1-1d.

Batocrinus unionensis Worthen, Geol. Surv. Ill., VII, p. 84, pl. XII, ff. 5-5a; pl. 13, f. 3, 1890.

"Body depressed globose, width at the base of the arms a little greater than the height to the base of the ventral tube. Plates of the calyx strongly beveled on the corners, leaving a deep suture between them on all sides. Dome elevated, composed of plates that are elevated in the center, forming short and rather stout nodes. Basal plates very small and concealed in the basal cup. First radials one and a half as wide as the second, and projecting so as to form a rim around the basal cavity. Second radials quadrangular and nearly twice as wide as long. Third radials pentagonal, axillary, and supporting on their upper sloping sides the secondary series. The secondary and tertiary radial series consist of three plates each, the last one of the third series giving support to the first arm plates. First anal plate hexagonal, and succeeded by two smaller ones in a double series. Arms composed of a double series of interlocking plates. Ventral tube slender, column unknown." (Rowley.)

Locality.—Lanesville.

DIZYGOCRINUS DECORIS Miller.

Plate XII, figs. 5-5a; Plate XVI, fig. 4.

Batocrinus decoris Miller, 17th Ann. Ind. Dept. Geol. Nat. Res., p. 671, pl. X, ff. 7, 8, 1892.

"Species above medium size; calyx depressed, nearly flat; radials form angular ridges from basals to free arms; interradial areas flattened, though the plates are somewhat convex and bear small tubercles or small coarse granules; arm openings horizontal.

"Basals three, forming a rather large disc, which bears a round or obscurely hexagonal rim extending below the radial ridges, and within which there is a deep concavity for the columnar attachment. First primary radials about four times as wide as long. Second radials quadrangular, about three and a half times as wide as long. Third radials pentagonal, nearly three times as wide as long and support the secondary radials. There are two second-

ary radials in each series; the first usually abuts two interradials and therefore becomes pentagonal, it is about twice as wide as long, the second is more than twice as wide as long, axillary, and supports upon each upper sloping side three tertiary radials. The tertiary radials are short and wide; each of the first ones abut an interradial; the second unite around the calyx, cutting off connection between the azygous area and the vault; they are axillary and bear either a double series of arm plates or bifurcating arms. The arms are not preserved in our specimen. There are twenty arm openings, four for each radial series.

"Regular interradials four; the first one is large, bears a central tubercle, and is followed by two of unequal size and length, and beyond the longer of these there is a narrow elongated plate that separates the tertiary radials and inserts an angle between the under sloping sides of the second tertiary radials. Azygous interradials eight and possibly nine; the illustration shows only five, but the lower central ones consist of two anchylosed plates and each of the upper ones should be divided. Vault high, conoidal, covered with unequal, more or less convex polygonal plates, three of which, above each of the five radial series, is produced into an obtuse spine. The proboscis is subcentral, and where broken off, in our specimen, rather large; length unknown.

"Found in the Warsaw group, at Spergen Hill, Indiana, and now in the collection of Wm. F. E. Gurley." (Miller.)

DIZYGOCRINUS? SP.

Plate XVII, fig. 7.

Specimen of rather small size, depressed subglobose, truncated below. Dorsal cup nearly flat to the upper costals, where it rounds slowly upward to the top of the distichals, which face outward. Vault somewhat flattened on the posterior side, quite full in the anterior region; tube small, subcentral, height unknown. Arms eighteen. Basals three, forming a shallow cup for the reception of the column, which covers about three-fourths their area. They are produced into a small ring below the radials. Radials rather large, hexagonal, slightly concave above. Brachials two, the first nearly as large as the radials, quadrangular; the second larger than the plates below, hexagonal, axillary, supporting two series of cos-

tals of two plates each, except in the anterior, in which there are three in the series, the last of which supports an arm. Distichals two in each series, supported by the axillary upper costals. Facets somewhat semicircular, or U-shaped. Arm openings large. The plates of the vault are convex and some are pointed. They are smaller and flatter on the posterior side. Interradials 1, 2, 1, the last supporting a narrow interambulacral connecting with the vault. Anal plate heptagonal, smaller than the radials, supporting 3, 3, 3, 2 plates, the last two supporting plates which connect with the vault. All plates of the calyx are somewhat convex. Each ray is marked with a bifurcating keel, reaching to the arms. The smaller surface markings are unknown.

Locality.—Lanesville.

Without the arms and complete tube it is impossible to refer this species to the proper genus. Until these are known it is of little use to apply a specific term to it.

The specimen belongs to Mr. G. K. Greene.

PLATYCRINUS BONOENSIS White.

Plate XIII, fig. 2.

Platycrinus bonoensis White, Proc. Acad. Nat. Sci. Phil., p. 30, 1878.

Wachsmuth and Springer's Description.—"Closely allied to the preceding species [*P. niotensis*], but having five to six arms to the ray instead of four, and these are proportionately shorter, more closely packed, and heavier. Dorsal cup wider than high, bowl-shaped, a little spreading, the margins of the plates slightly beveled, giving to the central portions a slight convexity. Surface without ornamentation.

"Basals proportionately small, forming a shallow basin, broadly truncated below and excavated at the bottom, the sides somewhat constricted so as to form a rounded projecting edge around the lower margins; the interbasal suture lines slightly elevated. Radials wider than long, gradually expanding upwards, the upper angles truncated, deeper at the anal side. Facets from one-half to two-thirds the width of the radials; semicircular. Costals small, trigonal, rarely covering the full width of the facets, and the distichals abut against the radials. First distichals once and a half

as wide as long, the axillary one a little wider and somewhat higher. The latter gives off an arm to the outer side of the ray and supports at the inner two palmers with two arms, making three arms to each subdivision, or six to the ray, exceptionally five. The arms are stout, especially in the middle, and quite short; they are uniserial to the fourth plate, beyond this biserial. Column slightly elliptic and twisted."

Locality.—Bono, Lawrence County.

PLATYCRINUS BOONVILLENSIS Miller.

Plate XIV, figs. 5-5b.

Platycrinus boonvillensis Miller, Bull. Geol. Surv. Mo., No. IV, p. 8, pl. I, ff. 1, 2, 1891.

Wachsmuth and Springer's Description.—"A rather large species of the type *P. burlingtonensis.* Calyx to the top of the radials bowl-shaped, wider than high, slightly pentagonal as seen from above. Plates moderately heavy, the surface smooth or nearly so; the basi-radial and interradial sutures grooved. Basals closely anchylosed, the lines of union elevated into ridges; they form a low, rapidly spreading basin, distinctly pentangular at the upper end, broadly truncated at the lower, the bottom deeply excavated so as to form a rounded, rugose rim around the column. Column facet circular, occupying one-half the concavity, its face covered with radiating striae. Radials a little wider than long, gradually expanding upwards, slightly more elevated along the median line, and somewhat beveled toward the sutures. The facets occupy less than half the width of the plates; they are shallow, directed upwards and surrounded by a projecting rim."

Locality.—Spergen Hill.

POTERIOCRINUS CORYPHAEUS Miller.

Plate XIII, figs. 1-1a.

Poteriocrinus coryphaeus Miller, 17th Ann. Rep. Ind. Geol. Surv., p. 654, pl. IX, f. 1, 1892. Avd. Sheets do, 1891.

"Species robust, arms large and long in comparison with the size of the calyx, and fit closely together. Calyx subturbinate, height a little more than the diameter; sutures distinct, surface granular.

Basals gradually expanding and forming a pentagonal cup. Subradials larger than the basals and longer than wide. The first radials about the same size as the subradials, wider than long, and truncated the entire width above and separated from the single brachials by a gaping suture. Brachials pentagonal, wider than long, rounded and constricted in the middle, and support free arms upon their sloping sides. In the ray on each side of the azygous area and in the one opposite the area, the brachials are followed, on each upper side, by a long, round, axillary plate, giving to each of these rays four arms. The two lateral brachials bear only two arms each. There are no other divisions of the rays. This gives to the species sixteen arms. The first plates are long, but they gradually shorten and become more and more cuneiform. The arms are flattened on the sides and fit closely together. Pinules long and coarse. The azygous area exposes five plates arranged as in other species in this genus. The first azygous plate is smaller than the second and rests between the upper sloping sides of the two subradials and the upper sloping side of the first radial on the right, and supports the third azygous plate. The second azygous plate broadly truncates a subradial. Column round, moderately large.

"Distinguished from other species by the number and character of the arms."

Locality.—Paynters Hill. The type was found in the Keokuk beds of Indian Creek, Crawford County, Indiana. The specimen figured is from the Paynters Hill, and belongs to the American Museum.

The specimen has the basal part of the calyx broken away, only the radials showing. The brachials in our specimen are about as wide as long, instead of wider than long, in this respect it approaches *P. amoena.*

ICTHYOCRINUS CLARKENSIS Miller and Gurley.

Plate XIV, fig. 4.

Ichthyocrinus clarkensis Miller and Gurley, Bull. V, Ill. St. Mus. Nat. Hist., p. 43, pl. IV, f. 5, 1894.

"Species small. Our specimen is compressed, but the general form with the arms folded is subovate. The plates are free from spines and nodes; the sutures are very distinct and slightly ar-

cuate, the superior plates generally overlap the inferior ones in the middle part. The column is very large and entirely covers the basals and subradials, so they have not been observed. There are no interradials.

"There are three primary radials in each series. They widen rapidly and are subequal in length. The different series interlock instead of having a straight separating suture. There are four secondary radials in each series of about the same length, and each plate has about the same length as a primary radial, they expand very little, so that the fourth axillary plate is not much wider than the first plate. The different series interlock in the same manner that the primary series do. The fourth plate supports upon each upper sloping side a single non-bifurcating arm, which gives the species twenty arms. The arms are composed of short quadrangular plates, with arcuate sutures. There are twelve plates in some of the arms on our specimen, and if complete there would probably be as many more."

Locality.—"Found in the Keokuk or Warsaw Group, in Clark County, Indiana, and now in the collection of Wm. F. E. Gurley."

DICHOCRINUS STRIATUS Owen and Shumard?

Plate XIII, figs. 5-5b.

Dichocrinus striatus Owen and Shumard, Jour. Acad. Nat. Sci. Phil. (2), II, p. 62, pl. VII, f. 10, 1850.

Calyx small, basal portion enlarging rapidly, sides convex, or approaching cup-shape, ornamented by about thirty lines radiating from the base in six rhombs. About eighteen of these lines reach the base. The sutures between the two basal plates lie in a narrow space which separates these markings into two distinct sets. The base is truncated below. The calyx is widest at the union of the basal and radial plates and somewhat constricted above. The sutures of the upper part of the calyx can not be made out in the specimen at hand. The top of the calyx is roughly pentangular, probably sometimes hexangular. There is a tendency of some of the lines of ornamentation to converge at the arm facets. The arm facets are roughly semicircular and small. The height is almost equal to the width. The columnar facet is round, small and

truncating the base of the calyx, bordered by the ends of the ornamental ridges.

Localities.—Paynters Hill, Harrodsburg.

The only complete calyx we have of this species is from Harrodsburg, and is quite small. It is to be remembered that these fossils become relatively much more robust with age, and the surface marks become, perhaps, better defined. While our specimen, and the basals from Paynter's Hill (agreeing better in some respects with the types), differ somewhat in form and markings from this species, it is referred here provisionally, as adult specimens might prove to be identical with *D. striatus,* notwithstanding the fact that, as yet, that species is not known to occur in rocks younger than the Keokuk.

DICHOCRINUS BLATCHLEYI N. SP.

Plate XVII, figs. 2-2f.

Dorsal cup deeply basin-shaped, truncated below for the attachment of the column, the facet surrounded by a small ring and bordered by the lower ends of the radiating ridges which form the surface marks of the lower part of the basal plates. These ridges are undulating and somewhat nodose, and end in the middle of the plate in a series of large pustules, above which are undulating transverse ridges, four or more, which may be either distinct, united with each other or broken. The plates are very thin. The radials, judging from loose plates, have about three horizontal ridges below, like the top of the basals, followed by six vertical ones on the upper part. The radials are wider below than above, higher than wide, with half or more of the top faceted for the reception of the superjacent structure. Facets semicircular with crenulated outer margins.

Locality.—Paynters Hill.

It is a dangerous thing to erect a species of crinoid upon surface marks, but in this limited genus of thin-plated crinoids there is no known species approaching this in its striking surface characteristics. They are much more like the surface features of some species of *Platycrinus.*

DICHOCRINUS OBLONGUS Wachsmuth and Springer.

Plate XIII, fig. 9.

Dichocrinus oblongus Wachsmuth and Springer, N. Amer. Crin. Cam., p. 759, pl. LXXVII, f. 9, 1897.

"In style of ornamentation resembling *D. striatus,* from which it differs essentially in its very elongate calyx and in the proportion of the plates. Calyx almost twice as high as wide, obconical, not contracted at the upper end; the sides convex. Surface covered by six sets of from five to six rather prominent, longitudinal ridges, which in gentle curves pass from the facets of the radials and top of the anal plate to the foot of the basals. These ridges do not cover the entire surface of the calyx, but leave upon the lateral margins of adjoining radials a trigonal space, divided by the interradial suture, and covered by obscure, longitudinal ridges, which rest obliquely against the other ridges.

"Basal cup conical, almost as high as the radials, and nearly as high as wide; slightly truncated at the bottom; the upper face but little excavated. Radials once and a half as long as the width at the lower end, a little wider above than below, the lower face almost straight; facets narrow, a little concave and slightly protruding outward. Structure of arms and ventral disk not known."

Locality.—"Near Bloomington."

TALAROCRINUS SP. CF. TRIJUGUS Miller and Gurley.

Plate XIII, fig. 8.

Calyx small, bowl-shaped, wider than high. Dorsal cup shallow, with small concavity below for the reception of the column; plates pentagonal and spreading to the base of the radials. Radials five, about as wide as high, quite convex in their central part and spreading rapidly from the top of the basals. About two-thirds the top faceted for the reception of the plates above, notched on the inner margin. Anal plate somewhat larger than the others and somewhat conical above. Surface smooth, sutures very distinct on account of the convexity of the plates. This is a young specimen, and can not be specifically determined without the vault. It is referred to Talarocrinus rather than to Dichocrinus, on ac-

count of the thickness of the plates. The specimen belongs to Mr. G. K. Greene.

Locality.—Lanesville.

TALAROCRINUS SIMPLEX Shumard.

Plate XIII, figs. 7-7c.

Dichorinus simplex Shumard, Trans. St. Louis Acad. Sci., I, p. 74, pl. I, ff. 2a, b, 1857.

Dichorinus constrictus Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 381, 1860, etc.

Wachsmuth and Springer's Description.—"A small species, the width of the calyx varying from 5 to 9 mm. Dorsal cup generally a little longer than wide, widest at the basi-radial suture or a little above, somewhat cylindrical along the medium portions, and generally contracting toward the arm bases. Plates thick, and without ornamentation or other markings; suture lines distinct, but not grooved.

"Basal cup large, semiglobose, extending to fully one-half the height of the calyx; the lower end slightly flattened, the central part excavated, forming a narrow circular pit of considerable depth; the salient angles at the upper margin quite obtuse, the re-entering angles toward the anal plate and the anterior radial comparatively sharp. Radials slightly differing in form, some being wider than others, but all, as a rule, longer than wide and narrowest at the top. The superior faces of the plates are directed obliquely inward, and the ends are but slightly truncated; they are excavated to one-half their width by the facets, which contain the costals and distichals. Anal plate generally wider at the bottom than the radials, but narrower at the top. Costals very minute. Distichals 1+10 in the calyx; of the same proportions as the overlying arm plates. Arms apparently ten, their structure and that of the ventral disk unknown."

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bloomington.

"This species has been heretofore referred to *Dichorinus,* with which, no doubt, it has some affinities; the presence, however, of a very minute costal, the form and arrangement of the distichals and succeeding brachials, show distinctly its relations with *Talarocrinus.*

The specimens vary considerably in size and somewhat in form; in most of them the sides of the calyx are evenly rounded, while in others they are contracted along the basi-radial suture. Meek and Worthen describe a specimen of this kind as a distinct species under the name of *D. constrictus*." (W. & S.)

Aside from these variations it should be remarked that the proportion of the calyx occupied by the basal plates varies with the age of the individual, being much less, relatively, in young specimens than in old ones, when it reaches to nearly one-half.

SYNBATHOCRINUS SWALLOWI Hall?

Plate XIII, fig. 11; Plate XIV, fig. 1.

Synbathocrinus swallowi Hall, Geol. Ia., I, pt. II, p. 672, pl. XVII, ff. 8, 9, 1858.

Calyx small, basin-shaped. The three basals form a ring around the columnar excavation, the five radial plates expanding rapidly upward, height about three-fourths the width, roughly quadrangular, except the two posterior ones, which have their two upper adjoining corners truncated, forming a notch and giving them a pentagonal outline. The top is faceted the entire width of the plate on the outer side, with a short ridge extending about half the width of the top of the plate; the inner edges of the plate. Lateral edges of the plate and the inner side turned up, the latter notched. At the posterior notch the edges of the plates are similarly turned up into the usual ridges, which extend inward almost like little teeth in some instances.

Localities.—Lanesville, Spergen Hill, Paynter's Hill.

The right lateral radial of one specimen is developed into a pentagonal piece by the elevation of its upper side into a pyramid, probably filling the place of the plate usually resting on it which had been removed by some accident.

Aside from the foregoing species there are plates, bases and portions of *Platycrinus, Actinicrinus?* and species probably belonging to other genera which can not be identified with sufficient certainty to be used here.

PENTREMITES CONOIDEUS Hall.

Plate XXVI, figs. 32, 33.

Pentremites conoideus Hall, Trans. Alb. Inst., IV, p. 5, 1856.
See previous chapter by Miss Essie A. Smith.

Rowley has described two varieties of *Pentremites conoideus* from Lanesville. I do not have these specimens before me, and I quote here his remarks concerning them.

PENTREMITES CONOIDEUS PERLONGUS Rowley.

Plate VII, fig. 7.

Pentremites conoideus var. *perlongus* Rowley, Cont. Ind. Pal., Pt. X, Vol. I, p. 87, pl. XXIX, f. 28, 1902.

"The greatest lateral diameter of the body is above the tips of the ambulacra, so that the form is almost barrel-shape, but with greater end diameter at the base. Like the typical form, this variety is strongly lobed; while from its extremely elongate shape, the plates are proportionately greater in length and less in width than in the broader forms. In outline this form is much like *Pentremites elongatus* from the Burlington limestone."

"In the author's collection is a specimen from Flag Pond, Va., so contracted at the base as to give a truly elongate elliptical outline on side view.

"The type of this variety is from the Warsaw limestone at Lanesville, Indiana, and now in the collection of Mr. G. K. Greene."

PENTREMITES CONOIDEUS AMPLUS Rowley.

Plate VII, figs. 8-8c.

Pentremites conoideus var. *amplus* Rowley, Cont. Ind. Pal., I, pt. X, p. 88, pl. XXIX, ff. 31-34, 1902.

"The width of these specimens is quite as great as the length, and the greatest lateral diameter is midway the body, giving a Granatocrinoid form to the fossil."

Locality.—Lanesville.

TROOSTOCRINUS.

Troostocrinus was proposed by Shumard in 1865 for *Pentremites laterniformis* and other fusiform pentremites, in a foot-note to that species, which reads: "There appear to me good reasons for removing this and other sub-fusiform species, as *Pentremites Reinwardtii, P. lineatus, P. bipyrimidalis, P. wortheni,* and perhaps *P. grosvenori,* from among the *Pentremites* and grouping them together as a separate subsection under another name. These and allied forms are remarkable in their slender, subfusiform shape, linear pseudambulacral fields, triangular base and summit structure. These external differences would seem to imply corresponding modifications in the internal economy of the animals of more than specific importance. If, from a thorough study of such species, it shall be deemed advisable to separate them from the genus *Pentremites,* I would propose the name TROOSTOCRINUS for the group, in honor of the late Dr. Gerard Troost, of Tennessee, among the earliest pioneers in American geology and palæontology."

In 1868 Meek and Worthen proposed *Tricoelocrinus* for the other extreme of the group with the implication that *T. woodmani* should be considered as the genotype.

After an exhaustive study of the Pentremites, Dr. Hambach, of St. Louis, revised the whole classification and grouped both the above genera and *Metablastus* of Etheridge and Carpenter in a single genus, and proposes the term *Sacoblastus* for it. This classification was made after an extended study of the pentremites, and is based on the apical structure, as he found the external form was of only specific value.

His definition of the genus is as follows:

"General form of the body pyriform, compressed cylindrically, or club-shaped. Ambulacra narrow and linear, generally, sunk into the fork piece sinus so that the surface does not touch the upper margin of the fork piece sinus. Lower part of the body shows three distinctly depressed areas; the amount of depression varies in different species. Interambulacral surface smooth or very finely striated. Summit opening never closed save by the ambulacral integument. Genital openings ten, of a slit-like appearance, on account of the orifice opening obliquely. Anal opening

so far below the genitals that in large specimens it is almost ¼ inch below the summit, and as far as known not covered. All specimens which I have had an opportunity to examine (over six hundred) did not show any sign of a covering. Column triangular. This genus comprises *Troostocrinus, Tricoelocrinus* and *Metablastus,* and to show the gradual transformation from one to the other I have given good figures of all our American species on plate IV. All described specimens are from the Warsaw limestone or below from the lower Subcarboniferous rocks."

In his revision he states that "All names ending in 'Crinus' are dropped" and proposes new ones in their stead. This is an unfortunate act, because of its violation of the rules of priority. While it might be pleasant to have appropriate or fitting names for genera and species, it is better to stick to rules of priority and thus have some escape from the chaotic confusion which would certainly result in the discarding of all names which might not suit the fancy of reviewers.

If these three genera are grouped together it is not, perhaps, beyond question whether *Troostocrinus* or *Tricoelocrinus* should be used. It is unfortunate that Shumard appended the footnote to *P. laterniformis,* thus implying that it was intended as the genotype, and which alone has been retained under *Pentremites.* However, his delineation of the characters of the group and the list of species referred to it leave no possible doubt as to his clear understanding of the salient characters of his proposed sub-genus, and the species to be referred to it. Add to this the fact that no genotype is signified, and it should be sufficient reason for retaining his name. In addition to this, it offers some little redress for the great wrong suffered by Dr. Troost at the hands of some of his contemporaries. Should it not be retained, *Tricoelocrinus* would have to be used and *T. Woodmani* would be the type of the genus.

The material at hand is not sufficient, or, for the most part, well enough preserved to warrant extended observations on the classification of the group. It is to be regretted that Hambach gave no detailed discussion of his reasons for combining these genera into one, and as a consequence we are obliged to follow Etheridge and

Carpenter's classification which seems to be based upon careful observation of fundamental characters, until Hambach shows that there is reason for abandoning it.

METABLASTUS WORTHENI Hall.

Plate XIV, figs. 8-8b.

Pentremites wortheni Hall, Geol. Rep. Ia., I, pt. II, p. 606, pl. XV, f. 1, 1858.

"Body elongate subfusiform; length of base and distance from base of radials to base of pseudo-ambulacral area, and length of the latter, about equal to each other. Base triangular. Basal plates very gradually spreading; upper margins concave for the reception of the radials. Radial plates long, narrow, almost linear; branches lanceolate. Interradial plates very small, acutely lanceolate, reaching very nearly to the summit. Pseudo-ambulacral areas very narrow, linear, extending downward about half the length of the radial plate, and one-third the entire length of the body. Each of these areas contains about thirty-five pore pieces on each side."

"Surface finely striated longitudinally and transversely."

Localities.—Lanesville, Bloomington.

According to Dr. Hambach this is a very variable species, the form probably depending upon the age of the particular individual. This author includes under this species *Metablastus nitidulus, M. varsoviensis, M. wachsmuthi* and *Troostocrinus grosvenori.*

TRICOELOCRINUS MEEKIANUS Etheridge and Carpenter.

Plate XIV, figs. 7-7b.

Tricoelocrinus meekianus Etheridge and Carpenter, Cat. Blast. Geol. Dept. Brit. Mus. Nat. Hist., p. 208, pl. XVI, ff. 17, 18, 1886.

Original description.—"Calyx slender, elongated pyramidal; summit very small and very much contracted; base with shallow lateral excavations; section pentagonal, with straight or flat sides; periphery rather nearer the base than the summit. Basal plates forming a low triangular cup, with the three carinae truncated, and not projecting below the central triangular surface which

bears the facet for the columnar attachment. Radial plates with slightly converging lateral margins; bodies much shorter than the limbs, and moderately carinate, the lateral basal excavations extending but little on their surfaces; limbs narrow with flat sides, not sloping at a high angle; sinuses three-quarters the length of the calyx with high sides; interradial sutures not in concavities. Ambulacra rather deeply sunken. Hydrospires unknown; Spiracles apparently mere slits only. Ornament not preserved."

Localities.—Spergen Hill, Paynters Hill?, Bedford, Bloomington.

There is a considerable difference in form between the specimens figured and the figure by Etheridge and Carpenter, but it is merely the difference in robustness of age. It has the nearly flat sides, truncated base and other characters separating it from the above species which is inserted for comparison. It may be found in the Salem limestone, but has not been as yet. It was described from the Harrodsburg limestone at Salem.

The stem of *Tricoelocrinus* is triangular instead of round, as stated by Etheridge and Carpenter.

TRICOELOCRINUS WOODMANI Meek and Worthen.

Text figs. 4, 5.

Pentremites obliquatus Roemer, Archiv. fur Naturgesch., Jahrg. XVII, p. 367, taf. VIII, ff. 11a, b, 1851.

Body large, pyriform, nearly flat below. Ambulacral areas very long, three-fourths the length of the individual, very narrow, deeply sunken beneath the surface of the body. About seventy-five poral pieces on a side. Radial pieces very long, quadrangular outwardly, terminating in points above the oral aperture. The two plates, which are truncated below to form two of the three excavations in the base, have the ambulacral angle extending downward from the end of the area a distance equal to one-third its length. They are then almost flatly truncated, the ridges connecting th e right posterior to those on either side may be so faint as to be scarcely noticeable; one ridge on the other plate is usually quite prominent. On this account the triangular columnar articulation is usually a little eccentric toward the ante-

rior. The basals form a shallow, ten-sided, irregular saucer, with three prominent ridges reaching to the center. Plates quadrangular and hexagonal, the three sutures falling in the three basal excavations. These three depressions of the base are shallow but distinct, tending to truncate the entire base. The surface of the specimens are covered with minute striae roughly parallel to the edges of the plates. Oral opening comparatively small. Genital openings quite small, opening beneath the tips of the radial (?) plates. Anal opening large, situated well down below the apex.

Localities.—Salem, Harrodsburg limestone.

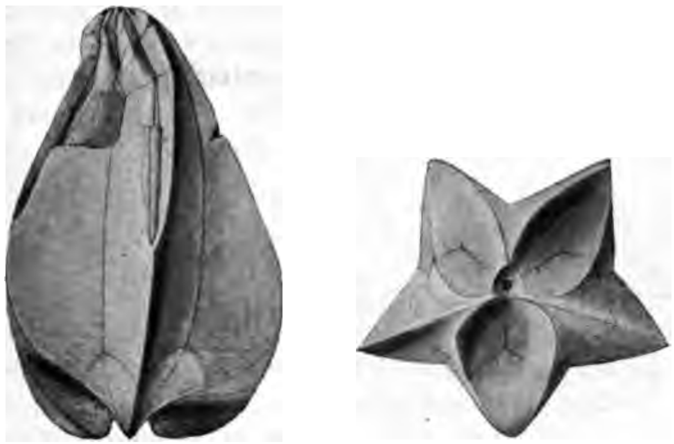
ARCHÆOCIDARIS NORWOODI Hall.

Plate XIV, figs. 6-6a; Plate XVIIA, figs. 5-5f.

Plates mostly hexagonal, wider than long, and of small size, Articulating process subtubuform in unweathered and unworn specimens, separated from the annulation by a pronounced furrow. Annulation distinct, being merely the top of the cylindrical elevation with elevated lines on the side which run out over the platform at the base and fade out before reaching its edge. Similar lines radiate from the margin of this platform across the excavated flattened surface of the plate toward the elevated nodose margins, but generally fade out before reaching it. These lines are usually fasciculated. The lateral margins may possess one, two, or three, or more rows of small crowded nodes, but the longer margins never have but a single row. Spines smooth except for extremely fine longitudinal lines, which extent their full length, and some indications of incipient spinules. Rarely are these spinules large enough to be noticed by the naked eye. They are mere longitudinal elevations, over which the fine surface lines extend. The annulation is strongly nodose in well preserved spines. Teeth, probably of this species (as the remains of no other have been seen) occur at Spergen Hill and are shown in the plate.

Localities.—Spergen Hill, Paynters Hill, Harrodsburg.

These specimens differ from *A. Norwoodi* in having the elevation and platform of the plates ornamented and in the relative smoothness of the spines.



a. *b.*

Fig. 4. A, lateral view, showing anal opening. B, basal view, showing the deed angles of the sides and the sharply produced keels and the sharply defined excavations of the base. In these characters it differs from *T. meekianus*.

Fig. 5. Lateral view, showing side nearly opposite to Fig. 4. The description and figures of this species are included here for comparison with *T. meekianus*.

TRICOELOCRINUS WOODMANI Meek and Worthen.

HOLOTHURIAN SPICULES?

Plate XIX, figs. 9-17.

Spicules resembling sand burs or stellate sponge spicules, but which seem likely to be Holothurian spicules abound in the Harrodsburg and Bloomington localities, with an occasional one at Spergen Hill and Paynter's Hill. They seem to be more abundant at Harrodsburg than anywhere else.

VERMES.

BY J. W. BEEDE.

SPIRORBIS IMBRICATUS Ulrich.

Plate XVII, figs. 5-5c.

Spirorbis imbricatus Ulrich, U. S. Prof. Pap. 36, p. 34, pl. IV, f. 10, 1905.

Shell spirally coiled at first, rather small, enlarging rapidly and becoming free, twisted trumpet-shaped in old individuals. The shell is ornamented with greatly produced concentric lamellae, which indicate the former location of the flaring orifice. There are smaller concentric marks between the large lamellae.

Localities.—Paynters Hill, Harrodsburg, Bedford.

This species is intimately associated with *S. annulatus* Hall, and the more slender small specimens with the lamellae somewhat worn are separated from it with difficulty. The points of distinction between the two are that *S. annulatus* has the lamellae much less developed and after the first whirl or two is passed it is cylindrical and always very slim, and when old develops into a cylindrical corkscrew, while the present species is more robust, enlarges more rapidly and when old develops into a twisted trumpet, with very highly developed scale-like lamellae, indicating growth stages.

SPIRORBIS ANNULATUS Hall.

Plate XVII, fig. 6; Plate XXVI, fig. 30.

Spirorbis annulatus Hall, Trans. Alb. Inst. IV, p. 34, 1856.

"Shell planorbicular, more or less ascending, irregular spiral; spire composed of about three turns, which are contiguous or more or less disconnected; umbilical side more or less deep and regular, according to the regularity of the spiral; surface ornamented with strong annulations, with finer striae between.

"Diameter from .062 to .25 of an inch." (Hall.)

Localities.—Paynters Hill, Spergen Hill, Harrodsburg, Bedford, Bloomington, Ellettsville, Stinesville, Romona.

"This species attains a rather larger size than is common with those of the genus. The coiling of the tube is very irregular, but always dextrally ascending from a small base of attachment, although the specimens are invariably found free. The annulating striae are strong, raised and lamellose, and form a very good distinguishing feature of the species." (Whitfield.)

It should be noted here that many specimens are found attached to bryozoa and corals and occasionally shells. The lamellae are less strong and less imbricating than in the preceding species and it is more cylindrical.

SPIRORBIS NODULOSUS Hall.

Plate XXVI, fig. 31.

Spirorbis annulatus var. *nodulisus* Hall, Trans. Alb. Inst., IV, p. 34, 1856.

"Shell in form like the preceding; last volution strongly deflected, volutions subangular, marked by oblique striae or ridges, which become strongly nodulose on the umbilical side, and particularly towards the aperture." (Hall.)

Localities.—Spergen Hill, Paynters Hill, Harrodsburg.

"The nodose character of this species is a strong distinguishing feature, and is entirely unlike the surface structure of the preceding one, being composed of oblique rows of thickened nodes, not capable of being formed by a modification of the distant, straight, encircling lines of the surface of that one, therefore I see no impropriety in classing it as a distinct species. It possesses about two or two and a half volutions, the latter part of the outer one being deflected to nearly an upright position and is free and cylindrical. Both these species in nearly every case show indications of having been fixed to some foreign substance when living and young, but are always, so far as I am aware, found loose in the rock. It would seem probable that they had been attached during life to some perishable substance, as a plant, which on decomposing had freed the tubes and allowed them to fall to the bottom of the water in a free state."

The specimens of this species have also been found attached. They are of very much more rare occurrence than *S. annulatus*, and have not been found in the "corkscrew form."

ORTONIA BLATCHLEYI N. SP.

Plate XIX, fig. 8.

Tubes quite small, rather crooked trumpet-shaped, enlarging gradually, solitary. The shell is moderately thin, with short, coarse, imbricating annulations with smaller ones between in specimens not waterworn; attached the entire length. The base is acute. Our specimens are small and attached to *Monilipora beecheri* Grabau.

Locality.—Bedford.

This fossil lacks the longitudinal striations of *T. Cornulites* and are attached throughout their entire length. In these points it agrees with Nicholson's genus *Ortonia* and is referred to it. There is no Carboniferous worm in America with which it may be confounded.

DESCRIPTION OF THE BRYOZOA OF THE SALEM LIMESTONE OF SOUTHERN INDIANA.

By E. R. Cumings.

Very few Bryozoa have ever been described from the famous oölitic limestones of Indiana, and those that have been described have found scant recognition in the literature. The ample list of species presented here, some of them new to science, and many of them well known forms in the equivalent formations of Illinois and Kentucky, will be a surprise to those geologists and paleontologists who have gained the impression from the famous Spergen Hill fauna of Hall and Whitfield that the Indiana oölitic contains only small dwarfed fossils. No better preserved fossils have ever been studied by the writer than these exquisite Fenestellids and other Bryozoa from the Dark Hollow quarries of Bedford—a town famous for its building stone, but hitherto unknown as a collecting ground for abundant and beautifully preserved fossils.

The Bryozoa described herein are from the top of the Salem formation and are contained in an exceedingly soft, loose-grained, greatly decomposed limestone, of such sort that it is possible to obtain free from the matrix portions of the fronds of practically all the species. The very wealth and wonderful preservation of the material has made the study replete with difficulties, because of the presence of characters that only the most perfectly preserved material could show, and which have therefore probably hitherto escaped notice, and because of the abundance of variations of all sorts.

A glance at the descriptions that follow will show that the fauna contains a number of forms characteristic of the Keokuk formation, and which have not hitherto been listed from above that horizon. The Warsaw species described from Bedford show differences from their equivalents in Illinois, perhaps dependent upon the exceptionally favorable conditions which must have obtained at the Indiana locality.

The distribution of this Bryozoan fauna in Indiana has not yet been adequately determined. Many of the species have been seen

at Bloomington, and some at Stinesville and Ellettsville. The localities farther south have not afforded many Fenestellidae. This is perhaps more due to the sort of preservation that obtains at Spergen Hill and other southern localities than to an actual absence of Fenestellids from the waters. *Hemitrypa Proutana* is usually present in these localities and with it a *Polypora* or two.

Where the stunted fauna comes in, as at Harrodsburg, Fenestellid Bryozoa are either absent or in such small fragments as to be nearly unidentifiable. At Harrodsburg small species of *Rhombopora* are fairly common.

Class BRYOZOA Ehrenberg.

Order GYMNOLAEMATA Allman.

Suborder CRYPTOSTOMATA Vine.

Genus FENESTRALIA Prout.

"Zoarium as in Fenestella, but with four rows of apertures, two on each side of the prominent median keel."

FENESTRALIA SANCTI-LUDOVICI Prout.

Plate XXVII, figs. 1-1a.

Trans. St. Louis Acad. Sci., I, p. 235, pl. 15, Figs. 1-1a.

"Zoarium a large flabelliform expansion. Branches 9.5 to 11.5 in one cm., rather slender and unequal, somewhat rigid, strongly carinated, the aperture bearing surfaces either flat or slightly convex; average width of branches 0.6 mm., increasing from 0.5 to 0.7 or 0.8 mm. between the bifurcations. Dissepiments rounded, depressed, expanding but little at their ends, about two-thirds the width of the branches. Fenestrules oblong sub-quadrangular or oval, their width varying from one-fourth to one-half the length; about six in one cm. longitudinally. Carina strong, rounded, dilating into prominent elongated tubercles at intervals of 1 mm. Zoœcia in four ranges, two on each side of the carina. Apertures sometimes alternating, usually opposite, those of the lower ranges opening obliquely or directly into the fenestrules and often obscured by those of the upper rows. * * * There are six or seven apertures in each row to a fenestrule, one of them opposite each dissepiment. The apertures are of medium size, surrounded

by a thin peristome, their diameter or a little more apart, with eighteen in 5 mm.

"On the reverse the branches are narrowly rounded, smooth or finely granulose, have sloping sides, are straight or slightly zigzag, and appear much thicker than on the opposite side." * * * (Ulrich, Geol. Surv. Ill., VIII, pp. 604, 605.)

Bedford, Indiana, rare.

Indiana University collection.

FENESTRALIA COMPACTA Ulrich.

Plate XXVII, fig. 2.

Geol. Surv. Ill., VIII, p. 605, pl. 59, Fig. 1.

Zoarial characters similar to those of *F. St.-ludovici*. Branches narrower, 11.5 to 12.5 to the cm. Nodes on the keel inconspicuous or wanting. Large nodes on the reverse. Dissepiments depressed, strong, rounded. Fenestrules 8 in one cm.

Bedford, Indiana, rather common.

Indiana University collection.

Genus FENESTELLA Lonsdale.

Murchison's Silurian System, p. 677.

Zoaria flabellate or infundibular, poriferous on one side; branches straight, or sometimes somewhat flexuous, connected at frequent intervals by non-poriferous cross-bars, called dissepiments. Zoœcia in two rows, one on each side of a median keel or row of spines or nodes. Reverse of branches usually striate or granular.

The original definition of this genus by Lonsdale restricts it to forms having the zoœcia on the *outside* of an infundibular zoarium —such forms as *F. Milleri,* which have recently, and the writer believes incorrectly, been placed in a separate genus, *Semicoscinium.* Lonsdale in the Geology of the Ural Mountains greatly widened his definition of *Fenestella,* making it include forms now placed in several more restricted genera. His original intent, however, was clearly to erect a genus for such forms as *F. Milleri,* having the zoœcia on the *outside* of the zoarium. By a strange irony of fate the genus has recently been restricted to forms having the zoœcia on the inside of the zoarium. The writer has made it

clear in his studies of the development of Paleozoic Bryozoa* that the classification of the Fenestellids is in an unsatisfactory condition, and that a satisfactory solution of the difficulties must be sought in the ontogeny of the various forms now referred to *Fenestella* and its related genera. The Mississippian forms are nearly all flabellate, hence they are in especial need of this sort of study in order to determine their true relationships to the *Fenestella* and *Polypora* groups as defined by the writer.† It is probable that a genus should be erected to receive persistently flabellate forms.

For the present the writer follows the customary usage in this country, which we owe to Mr. E. O. Ulrich, and which considers *F. plebeia* McCoy as the genotype.

FENESTELLA RUDIS Ulrich.

Plate XXVII, fig. 3-3b.

Geol. Surv. Ill., VIII, p. 537, pl 49, Figs. 3-3d.

Zoarium a large flabellate expansion. Branches flexuous, stout, about 0.3 mm. in diameter, 16 to 18 in one cm., approaching each other somewhat at the dissepiments. Fenestrules oval in the younger portions of the zoarium, rounded in the older portions; 10 to the cm. Zoœcia large, peristomes inconspicuous; 4 to 5 zoœcia to the fenestrule, 22 in 0.5 cm. Carina medium strong and carrying a row of large spines 0.5 mm. or more apart. In weathered specimens the carina appears much narrower and sharper. Reverse of branches rounded, and with a number of large low spines to the fenestrule, especially at the angles of the fenestrules. Mr. Bassler would consider this a good variety of *F. rudis*.

Bedford, Indiana, rather common.

Indiana University collection.

FENESTELLA COMPRESSA var. ELONGATA n. var.

Plate XXVIII, figs. 1-1b and 2-2c.

Zoaria consisting of flabellate expansions of very lax growth. Branches small, narrow, rounded, sometimes slightly flexuous, about 0.15 to 0.25 mm. in diameter, and 12 to 16 to the cm. Fen-

*Am. Jour. Sci., Vol. xvii, January, 1904.
†*Op. cit.*

estrules oblong to quadrate, 7 to 9 in 1 cm., the length of a fenestrule varying from 0.8 to 1.3 mm. and the breadth from 0.3 to 0.5 mm. On the reverse the quadrate or rectangular appearance of the fenestrule is much more pronounced than on the obverse; hence on the obverse they frequently appear oval or elliptical. Zoœcia rather small, 0.075 mm. in diameter, without pronounced peristomes, slightly indenting the fenestrules; 5 or 6 zoœcia to the fenestrule. The carina is high and narrow and bears an occasional conspicuous spine. Reverse of branches rounded, either smooth or with a number of spines to the fenestrule, which are sometimes very long and sharp.

Bedford, Indiana, not common.

Indiana University collection.

FENESTELLA EXIGUA Ulrich.

Plate XXVIII, figs. 3-3a.

Geol. Surv. Ill., VIII, p. 545, pl. 51, figs. 1-1a.

Zoarium forming large flabelliform expansions. Branches somewhat flexuous, 18 to 20 to the cm., 0.15 to 0.45 mm. in diameter. Fenestrules oval, 12 to 14 to the cm. Zoœcia small, from 4 to 5 to the fenestrule. Carina narrow, elevated, carrying 2 or 3 low spines to the fenestrule. Reverse of branches rounded, with a strong node at each end of the dissepiments, and a few nodes scattered irregularly over other portions of the branches.

Bedford, Indiana, rather rare.

Indiana University collection.

Normal range Warsaw.

FENESTELLA MULTISPINOSA Ulrich.

Plate XXIX, figs. 1-1e.

Geol. Surv. Ill., VIII, p. 540, pl. 50, figs. 3-3d.

Zoarium flabellate, expanding rapidly because of the frequent bifurcation of the branches. Branches straight, 0.3 to 0.5 mm. in diameter; 18 to 20 in one cm. Fenestrules round to oval in the basal region, rectangular near the growing margin; 13 to 15 in one cm. Zoœcia about 0.1 mm. in diameter, 3 to 4 to the fenestrule; in the older portions of the zoarium usually operculate. Obverse

with a row of small nodes on the not very prominent carina, and with the carinate dissepiments often elevated into a distinct spine which is sometimes very prominent. Reverse granular-striate in the younger portions and strongly granular in the older portions of the zoarium. The large regularly arranged nodes shown in Fig. 1-c have not been observed in any other specimen. This latter specimen may prove to belong to a distinct species, but for the present I prefer to include it here.

Bedford and Bloomington, Indiana, very abundant.

Indiana University collection.

Normal range Keokuk.

FENESTELLA TENAX Ulrich.

Plate XXX, fig. 1; XXXI, figs. 1-1b.

Bull. Denison University, IV, p. 71.

Zoarium consisting of very delicate, closely arranged, rounded branches, bifurcating at long intervals; 28 to 30 branches to the cm. Diameter of branches 0.15 to 0.45 mm., the latter measurement being just below a bifurcation. Fenestrules oval, indented by the zoœcia; 22 to 23 to the cm. Zoœcia very small, with prominent peristomes. Three zoœcia to the fenestrule, 26 in 0.5 cm. Carina usually elevated and narrow, often carrying a row of small spines, one to each zoœcium. Reverse granular-striate. Dissepiments very narrow, slightly expanded at their junction with the branches.

Bedford, Indiana, rather common.

Indiana University collection.

Normal range Waverly to Chester.

FENESTELLA TENAX var. MULTINODOSA n. var.

Plate XXXI, figs. 2-2a.

Dimensions the same as in *F. tenax,* but with a row of small spines along the carina, from 4 to 5 to the fenestrule, and arranged in a zigzag line. Only a few specimens of this form have been seen.

Bedford, Indiana, very rare.

Indiana University collection.

FENESTELLA SERRATULA Ulrich.

Plate XXX, figs. 2-2c, 3-3a.

Geol. Surv. Ill., VIII, p. 544, pl. 50, figs. 5-5c.

Zoarium a foliar expansion. Branches small, straight, bifurcating at rather frequent intervals, 0.15 mm. to 0.45 mm. in diameter; from 22 to 26 to the cm. Fenestrules oval to rectangular, 15 to 20 to the cm. Zoœcia small, 2 to 3 to the fenestrule, 22 to 0.5 cm. Carina line-like, or when perfect fairly prominent, surmounted by a row of small, rather sharp spines, one to each zoœcium. Reverse rather strongly striated and granular. Dissepiments very narrow, slightly expanded at their junction with the branches, slightly carinate on the obverse. A very variable species.

Bedford, Indiana, common.

Indiana University collection.

Normal range Keokuk to Chester.

FENESTELLA TENUISSIMA n. sp.

Plate XXX, fig. 4.

Only a few specimens of this delicate form have been seen. It strongly resembles *F. perminuta* of the Lower Coal Measures. The excessive tenuity of the dissepiments and small size and wide separation of the zoœcia place this form in strong contrast with any of its associates in the Salem limestone. Branches flexuous, very narrow, 0.15 to 0.2 mm. in diameter; 20 to 24 to the cm. Fenestrules rectangular, indented by the zoœcia; 13 fenestrules to the cm. Zoœcia very small, separated by more than their diameter, and with prominent peristomes. Three to four zoœcia to the fenestrule. Dissepiments very narrow, striated, slightly expanded at each end. Reverse of branches finely striated. Carina very narrow and low, with an occasional low spine.

Bedford, Indiana.

Indiana University collection.

FENESTELLA SERRATULA var. QUADRATA n. var.

Plate XXXI, figs. 3-3a.

Zoarium flabellate. Branches round, bifurcating at long intervals, 0.15 mm. in diameter, 20 to 21 to the cm. Fenestrules quad-

rate to oblong, 15 to the cm. Indented by the zoœcia. Dissepiments about one-half as wide as the branches, slightly expanded at their junction with the latter, conspicuously striate. Zoœcia small, distant, with moderately prominent peristomes; 3 or 4 to the fenestrule. Carina scarcely at all elevated and without spines. Reverse faintly granular-striate. The strikingly quadrate appearance of the fenestrules is the chief characteristic of this variety. An extreme form of *F. serratula*.

Bedford, Indiana, common.

Indiana University collection.

Genus HEMITRYPA Phillips.

Paleozoic Fossils, p. 27.

"Zoaria funnel-shaped or undulating foliar expansions; branches rigid. Zoœcia in two ranges, their apertures separated by a moderately developed keel. The latter is elevated at regular intervals into small pillars, which, when the superstructure they support is worn away, appear as spine-like prominences. The superstructure consists of straight or zigzag longitudinal bars, of which one is placed over each branch upon the row of pillars, and another usually somewhat thinner, suspended midway between the branches. These bars are then connected by transverse processes, so as to leave regular, small, generally hexagonal openings, corresponding in number and position with the zoœcial apertures beneath them." (Ulrich, Geol. Surv. Ill., VIII, p. 396.)

HEMITRYPA PROUTANA Ulrich.

Plate XXXII, figs. 2-2b.

Fenestella Hemitrypa Prout.

Geol. Surv. Ill., VIII, p. 560, pl. 57, figs. 1-1c.

Trans. St. Louis Acad. Sci., I, p. 444, pl. 17, figs. 4, 4a.

"Zoarium a large flabellate or semi-infundibular expansion, more or less undulated toward the free margins. Obverse or inner side protected by a delicate network, formed by the union of longitudinal and transverse bars. The former consists of two kinds, a slightly stronger and more prominent set, which are developed directly over the center of the branches and united to

them by short supporting pillars. These may be called the *principal* bars. A second set, which alternates with the principals and may be known as the *secondary* bars, are suspended over the space between the branches. The network is completed by a set of short transverse bars [scalæ]. * * * Measuring transversely, about twenty-six rows of interstices occur in 5 mm.; longitudinally about twenty-four. One to three small denticles sometimes project from the bars into the interstices. When this network has been denuded * * * the obverse face of the branches is seen to be ridge-shaped, from 0.2 to 0.32 mm. wide, and generally 26 in 1 cm. The median carina is neither sharp nor prominent, but carries small nodes (the broken pillars that support the superficial network) at intervals corresponding with the length of the zoœcia. Dissepiments very short, depressed, about half as wide as the branches. Fenestrules long-oval, small, about 0.3 by 0.1 mm., and 18 or 19 in 1 cm. Zoœcia in two ranges, 23 or 24 in 5 mm., with small, widely separated, circular apertures, and elevated peristome.

"On the reverse the branches and dissepiments are on the same plane, usually ridge-shaped, forming quadrangular fenestrules of greater width than on the opposite face. On mature examples the branches are smooth or very finely granular. On young ones they are faintly striated." (Ulrich, *loc. cit.*)

Bedford, Bloomington, Spergen Hill, Lanesville and Edwardsville, Indiana, rather common.

Collections of American Museum, National Museum and G. K. Greene.

Normal range Keokuk to St. Louis.

HEMITRYPA PROUTANA var. NODODORSALIS n. var.

Plate XXXII, figs. 1-1c.

Dimensions and characters of the superstructure same as in *H. Proutana,* but with a conspicuous node at each angle of the fenestrules on the reverse; and branches and dissepiments more rounded than in that species. This is the commonest *Hemitrypa* at Bedford.

Bedford, Indiana, common.

Indiana University collection.

HEMITRYPA BEEDEI n. sp.

Plate XXXII, figs. 3-3c.

Zoarium and infundibular expansion attaining a size of several cm., undulating. Branches rigid of very uniform breadth, scarcely departing from 0.3 mm. except just above and just below a bifurcation. Bifurcations remote, so that the frond expands very slowly. There are 24 branches to the cm. Fenestrules very narrow in fully developed portions of the zoarium, almost slit-like, especially as seen from the reverse, 19 to 20 to the cm. The ratio of length to breadth may be as great as 7 to 1. The normal breadth of a fenestrule is 0.125 to 0.15 mm., and the length 0.3 to 0.35 mm. Dissepiments very short, depressed, and where the fenestrules are narrowest, scarcely visible at all. They have much the same appearance on both the obverse and reverse.

Superstructure consisting of pentagonal and hexagonal interstices, 24 in 0.5 cm., both longitudinally and transversely; strongly indented by three or four knob-like tubercles, giving them a decidedly floriform appearance. The primary bars are elevated above the general level of the interstices, forming a rather conspicuous ridge over each branch.

The reverse of this species is very characteristic. The branches are flattened and strongly marked by five or six granulose striæ. In this respect the resemblance to *H. peristriata* is very close, but the lines of nodes are lacking. Other differences from *H. perstriata*, its nearest ally, are the floriform, polygonal interstices, and the dimensions; the latter species having 20 to 22 branches and 14 or 15 fenestrules to the cm., whereas the present species has 24 branches and 19 to 20 fenestrules to the cm.

Bedford, Indiana, rare.

Indiana University collection.

Genus POLYPORA McCoy.

Synopsis of the Carboniferous Fossils of Ireland, p. 206.

Zoaria similar to *Fenestella* in general shape and either infundibular or flabellate. Zoœcia on one side of the branches, in more than two rows. Median keel lacking. A row of tubercles sometimes occupies the median line of the obverse of the branches. Dissepiments non-poriferous. Reverse smooth or striate.

The relationships of this genus have been discussed by the writer in his memoir on the Development of Paleozoic Bryozoa.* It was shown there that in its ontogeny it is very different from *Fenestella*, and probably with its associates entitled to rank in a separate family. The above diagnosis follows the present usage in this country, but will need some modification when the development of the forms now referred to the genus is made known.

POLYPORA SIMULATRIX Ulrich.

Plate XXXIII, figs. 1-1b.

Geol. Surv. Ill., VIII, p. 589, pl. 59, figs. 4-4b.

Zoarium a very large wavy flabellate expansion, the largest seen being 18 cm. wide and 10 cm. long. Branches large, slightly sinuous, diameter varying considerably, from 0.6 to 1.25 mm., the average being about 0.75 mm. On the obverse the branches are broadly rounded or flattened, while on the reverse they descend rather abruptly into the fenestrules on either side and are often considerably flattened on the back. Reverse very finely granular. Eight to ten branches to the cm. Fenestrules suboval to rectangular, the latter appearance is especially characteristic of the reverse; 2.5 to 4.5 mm. long, 0.3 to 0.8 mm. broad. Zoœcia large, 0.1 to 0.15 mm. in diameter; in 3 to 5 alternating rows. Peristomes well developed, especially in the older regions of the zoarium, where they are very prominent. In the younger portions of the zoarium the zoœcia are conspicuously elliptical in shape, with their longer axis in the direction of the branch, or, in the case of those in the outside rows, oblique to the direction of the branch. In the older portions of the zoarium the zoœcia appear more rounded. There are normally seven zoœcia in a row to the fenestrule; 15 in 0.5 cm. Dissepiments slender, striated, 0.15 to 0.45 mm. in diameter scarcely expanded at their ends, sometimes running rather obliquely from branch to branch.

This is one of the largest polyporas in the Mississippian rocks, being fully as large as *P. Halliana* and *P. Maccoyana,* and differing from both in the absence of granules on the obverse, and in

*Am. Jour. Sci., Vol. xvii, January, 1904.

the conspicuous peristomes, and in the elliptical apertures and striated dissepiments.

Bedford and Bloomington, Indiana, common.

Indiana University collection.

Normal range Keokuk.

POLYPORA STRIATA n. sp.

Plate XXXIII, figs. 2-2a.

Zoarium a large flabellate expansion. Branches rigid or slightly flexuous, 0.4 to 0.9 mm. in diameter, 11 or 12 to the cm., obverse rounded and spinose, reverse flattened, distinctly striated. Fenestrules oval to subquadrate, 0.6 to 0.9 mm. long by 0.3 to 0.6 mm. wide, 6 to 8 to the cm. Zoœcia in two or three ranges, somewhat irregularly disposed, small, about five in a row to the fenestrule. Dissepiments narrow, round on the reverse, 0.15 to 0.2 mm. in diameter, expanded at their junction with the branches (especially on the obverse), and slightly carinate on the obverse. On the obverse there are one or two strong spines to the fenestrule. The reervse is marked by well defined, longitudinal striæ, except in the older part of the zoarium.

Bedford, Indiana, rare.

Indiana University collection.

POLYPORA INTERNODATA n. sp.

Plate XXXIV, figs. 1-1a.

Zoarium a flabellate expansion. Branches somewhat sinuous, flattened on the reverse, rounded on the obverse, varying considerably in diameter—from 0.25 to 0.75 mm. Ten to twelve branches to the cm. Dissepiments short, very narrow, 0.2 mm. in diameter, striated on the obverse and depressed; about on a level with the branches on the reverse, and each dissepiment bearing a stout, round spine, midway between the branches. On the reverse the dissepiments appear shorter than on the obverse. Fenestrules varying greatly in size and shape, usually oval to elliptical, from 0.2 to 0.6 mm. wide and from 1.0 to 1.5 mm. long; 7 to 8 fenestrules to the cm. Zoœcia large (0.15 mm. in diameter), round, with

prominent peristomes; and in two to four ranges, four in a row, to the fenestrule, 14 to the half cm. The prominent spines on the dissepiments will distinguish this species from all others.

Bedford, Indiana, rare.

Indiana University collection.

POLYPORA BISERIATA Ulrich.

Plate XXXIV, figs. 2-2b.

Geol. Surv. Ill., VIII, p. 592, pl. 60, figs. 4-4b.

"Zoarium a slowly expanding, irregular, more or less undulating, foliar network, from four to eight cms. in height. Branches closely approximated, 17 to 19 in 1 cm., slender, averaging 0.5 mm. in width, but increasing from 0.4 to 0.7 mm. before bifurcation, which takes place at intervals of from 5 to 14 mm. Their periferous surface is nearly flat or slightly elevated centrally, where a row of prominent spines or nodes about 0.45 mm. apart, almost give the impression of a median keel. Dissepiments short, depressed, one-half or less than one-half the width of the branches. Fenestrules small, suboval, about 14 in 1 cm. Zoœcia in two alternating ranges, increasing to 3 at a point 2 or 3 mm. below the branch divisions. Apertures large, 0.15 mm. in diameter, direct, with prominent peristome, 17 or 18 in 5 mm., their diameter or less apart, often closed by an opercular cover of the usual type. On the reverse the branches are rather broadly rounded, somewhat channeled below the bifurcations, and either smooth or very finely striated; the dissepiments thin and not depressed, and the fenestrules sub-quadrate." (Ulrich, *loc. cit.*)

The Indiana specimens of this species have 15 to 16 branches and 12 fenestrules to the cm., but in other respects correspond very closely to the description given above.

Bedford, Indiana, rather rare.

Indiana University collection.

Normal range Warsaw.

POLYPORA MACCOYANA Ulrich.

Plate XXXIX, fig. 1; Plate XL.

"Zoarium a large, flabellate, slowly expanding frond. Branches 6 to 8 in 1 cm., strong, rigid, subcylindrical, often with a row of widely separated and exceptionally large spines, which usually

take the place of a cell aperture. Though varying from 0.6 to 1.2 mm., the average width of the branches is between 0.8 and 0.9 mm. Surface minutely granulose. Dissepiments slender, rounded, depressed. Fenestrules oblong subquadrate to elongate-oval, of variable width, averaging 2.4 by 0.8 mm. [not so long in the present examples], with 3 to 3.5 in 1 cm. [4 to 6]. Zoœcia in from 4 to 8 alternating ranges, normally in 5 or 6. Apertures 14 or 15 in 5 mm., subcircular, without peristome, appearing larger in worn examples than in perfect ones, widely separated longitudinally, and arranged in more or less regular intersecting diagonal series. Reverse of branches and dissepiments convex and finely striated.

"This species, although closely related to *P. halliana* Prout, can not be confounded with it. The fenestrules are so much longer, the branches stronger, more rigid and cylindrical, that a glance suffices to distinguish them. *P. simulatrix* resembles it more in its general aspect, but differs widely in important characters." (Ulrich, Geol. Surv. Ill., vol. VIII, pp. 588, 589.)

Bedford, Indiana, rare.

Indiana University collection.

POLYPORA SPININODATA Ulrich.

Plate XXXIX, figs. 2, 3.

Zoarium a foliar expansion. Branches stout, broadly rounded on the obverse, 0.4 to 0.6 mm. in diameter 14 to 15 to the cm. Fenestrules oval 0.35 by 0.65 mm.; 11 to the cm. on the average. Zoœcia large, with prominent peristomes, arranged in 3 or 4 alternating rows; 0.1 to 0.15 mm. in diameter. Reverse rounded and with large hollow spines at intervals. The only specimen in my collection is poorly preserved, but has the general appearance and measurements of this species.

Bedford, Indiana, very rare.

Indiana University collection.

PINNATOPORA SP?

Plate XXXIV, figs. 3-3a.

Two specimens of what seem to be fragments of the fronds of *Pinnatopora* have been found in the Bedford material. These are not of a nature to warrant more accurate identification.

Bedford, Indiana, very rare.

Indiana University collection.

Genus DICHOTRYPA Ulrich.

Geol. Surv. Ill., VIII, p. 386.

"Zoaria consisting of large, thin, bifoliate expansions. The surface with solid maculæ. Zoœcial structure in conformity with that given for the family [Cystodictyonidæ]." (Ulrich, *loc. cit.*)

DICHOTRYPA FLABELLUM (Rominger).

Plate XXXIV, fig. 4.

Proc. Acad. Nat. Sci., Phila., 1866, p. 122.

"Zoarium having a strong, expanded base, roughly marked on the lower side with a concentrically wrinkled epitheca. On the upper side the base gradually contracts into a flattened or subcylindrical stem, which soon expands again into a bifoliate, fan-shaped frond, from 1.5 to 4.0 mm. in thickness, and several cm. in width and height. The base, stem, and lower portion of large examples is covered with a faintly striated dermatic crust. Above this the surface presents solid substellate maculæ, 4 or 5 mm. apart, bordered by apertures very slightly larger than the rest. In the perfect state the apertures are oval, 0.12 to 0.15 mm. in length, with the lunarium on one side more or less elevated. In the ordinary state of preservation they appear much larger (about 0.2 mm.) and the interspaces correspondingly narrower. The apertures are regularly arranged in intersecting lines, sometimes with six, but more commonly with seven in three mm. Interspaces generally a little elevated, and when well preserved covered with fine flexuous striæ. These also occur on the surface of the maculæ." (Ulrich, Geol. Surv. Ill., VIII, p. 501.)

Spergen Hill, Bloomington, Stinesville, and Lanesville, Indiana, very abundant.

Indiana University collection.

DICHOTRYPA SP?

Plate XXXV, fig. 6.

A single specimen from Stinesville, Indiana, has the following characters: Zoarium a thin bilaminar expansion. Zoœcia smaller than in *D. flabellum,* 0.1 to 0.15 mm. in diameter, 10 to 11 in 5 mm., arranged in intersecting lines. The margins of the aper-

tures are scarcely elevated, except on the lunarial side; those surrounding the maculæ are larger than those in the interval between maculæ (about 1.5 mm. in diameter). The maculæ are elongate, perfectly smooth, bounded by seven or eight zoœcia with their lunaria facing the macula, and 1.5 mm. apart.

This form may be referable to the common *D. flabellum*.

Stinesville, Indiana, very rare.

Indiana University collection.

Genus CYSTODICTYA Ulrich.

Jour. Cincinnati Soc. Nat. Hist., V, pp. 152, 170.

"Zoaria ramose, bifoliate, the branches acutely elliptical in cross section, with sub-parallel, sharp, non-poriferous, striated, granulose, or smooth margins. Zoœcia apertures generally arranged in longitudinal series between ridges, sometimes in more pronounced oblique rows. Apertures sub-elliptical, partially closed in the fully matured condition, with a more or less developed lunarium, that is always situated upon the side nearest to the margin of a branch. Interspaces finely striated, granulose or smooth, and never with pits or cells, excepting when worn." (Ulrich, Geol. Surv. Ill., VIII, p. 385.)

CYSTODICTYA LINEATA Ulrich.

Plate XXXV, fig. 1.

Jour. Cincinnati Soc. Nat. Hist., VII, p. 37, pl. II, 4-4c.

Zoarium bifoliate thin, 4 to 5 mm. wide, consisting of strap-like bifurcating fronds with sharp edges. Zoœcia in 8 to 10 parallel ranges separated by very low ridges, which appear much more prominent in weathered than in well preserved specimens; alternating in adjacent rows, about 11 zoœcia in 0.5 cm. longitudinally, and 12 in 0.5 cm. diagonally. Where well preserved the sides of the zoœcia nearest the margins of the branch is elevated, hood-like. Spaces between zoœcia faintly and finely striated and granulose.

Spergen Hill, Bloomington, Lanesville and Paynters Hill, Indiana, common; Bedford, Indiana, rare.

Indiana University collection.

CYSTODICTYA OCELLATA Ulrich.

Plate XXXV, fig. 2.

Two specimens from Bedford, Indiana, have the appearance shown in pl. IX, fig. 2. There are practically no ridges between the rows of zoœcia, and the whole surface between zoœcia is uniformly covered with fine granules and fine sinuous striae. These are probably only exceptionally well preserved examples of *C. ocellata.*

Genus WORTHENOPORA Ulrich.

Geol. Surv. Ill., VIII, p. 403.

"Zoaria bifoliate, branching or palmate. Zoœcia very regularly arranged, subtubular, or rather, elongate rhomboidal, with the aperture semi-elliptical. On the surface the line of junction between the cells is marked by an elevated ridge. The truncated posterior margin of the aperture is raised into a less strong transverse bar. The elongate triangular depressed front appears perfectly plain." (Ulrich *loc. cit.*)

WORTHENOPORA SPINOSA Ulrich.

Plate XXXV, fig. 3.

Geol. Surv. Ill., VIII, p. 669, pl. 68, figs. 1-1g.

"Zoarium a bilaminar elongate frond, 3 or 4 mm. wide, 0.5 to 0.8 mm. in thickness, branching dichotomously or otherwise at long intervals. Acutely elliptical in cross section. Margins subparallel, armed with a series of slender spines from 0.3 to 0.5 mm. long, pointing obliquely upward and outward. There are on each side about 16 in 3 mm. Zoœcia enclosed by an elevated sub-angular ridge, common to adjoining zoœcia. The space enclosed is elongate, somewhat rhombic in shape, drawn out long wedge-shaped posteriorly, and more rounded anteriorly; the whole usually 0.6 mm. long and 0.12 mm. wide. Aperture semi-elliptical, truncated posteriorly, 0.18 mm. long, and 0.1 mm. wide, occupying the anterior third of the space enclosed by the ridges, which form its margin except at the posterior side, where a thinner and less elevated line separates the aperture from the remainder of the enclosure. The latter forms an irregular subtriangular depressed space, with the bottom smooth and slightly

concave. When perfect five small tubercles, one on the posterior and two on each of the lateral margins, project into the aperture. Apertures arranged in regular, acutely intersecting, diagonal series, 9 in 3 mm., and in less regular transverse rows, between 8 and 9 in 2 mm. The marginal rows of zoœcia are usually a little larger than the central ones." (Ulrich, *loc. cit.*)

My specimens do not show the marginal spines, and differ slightly in the measurements, but are evidently referable to this species.

Bedford and Bloomington, Indiana, rare.

Indiana University collection.

Normal range Keokuk.

WORTHENOPORA SPATULATA (Prout).

Plate XXXV, fig. 4.

Trans. St. Louis Acad. Sci., I, p. 446, pl. 17, figs. 2-2c.

"This species differs from *W. spinosa* mainly in the form of the zoarium, which is always more explanate, being usually of flabellate form. The margins are sharp and striate, and without spines. On one fragment many of the triangular suboval spaces are divided in half by a thin transverse ridge." (Ulrich, Geol. Surv. Ill., VIII, p. 670.)

Bedford, Indiana, very rare.

Indiana University collection.

Normal range Warsaw.

Genus RHOMBOPORA Meek.

Paleontology of Eastern Nebraska, p. 141.

"Zoaria slender, ramose, solid. Zoœcia with the vestibular or outer portion thick-walled. Apertures arranged regularly in diagonally intersecting or longitudinal lines. Strong acanthopores often present at the angles of junction and more numerous, smaller spines generally occupy the summit of the ridge-like interspaces between the sub-elliptical apertures. Diaphragms sometimes present in the axial region." (Ulrich, Geol. Surv. Ill., VIII, p. 402.)

RHOMBOPORA BEDFORDENSIS n. sp.

Plate XXXV, fig. 5.

Zoarium consisting of branching cylindrical solid stems arising from an expanded poriferous base. Diameter of branches 1.25 to 1.75 mm., and fronds attaining a length of several cm. Zoœcia elliptical, about 0.075 mm. wide by 0.15 mm. long, arranged in regular diagonal intersecting rows about 4 to 5 in 1 mm., and about 3 in 1 mm. when measured along the longitudinal rows. The area about the mouth of the zoœcia is somewhat depressed. Opposite the lower end of each zoœcium is a prominent node, situated about one-third to one-fourth of the distance from this zoœcium to the next zoœcium below—i. e., toward the base of the branch. Besides these nodes there are on the older portions of the zoarium very obscure granules.

Bedford, Indiana, rather rare; Bloomington, Stinesville and Harrodsburg, abundant.

Indiana University collection.

Genus FISTULIPORA McCoy.

Ann. Mag. Nat. Hist., Ser. 2, III, p. 131.

"Zoaria massive, lamellate, parasitic or free, with a wrinkled epitheca below; less commonly sub-ramose, the branches solid or hollow. Zoœcia subradially arranged about the surface maculæ, with ovoid, sub-triangular or pyriform apertures, the variations being due to the degree in which the lunarium is developed; internally with thin walls and a small number of complete horizontal diaphragms. Interspaces smooth or granular, internally occupied by one or more series of vesicular cells." (Ulrich, Geol. Surv. Ill., VIII, p. 382.)

FISTULIPORA SPERGENENSIS Rominger.

Plate XXXVI, figs. 5 and 6.

Proc. Phila. Acad. Sci., p. 122.

"Undulated convexo-concave laminæ, or strumose utricles and cyst, with an epitheca on the inner or inferior side. Tubules one-third of a millimeter wide, distant less than their own diameter. Orifices circular, surrounded by an elevated rim, which projects

more on the outer side. Many specimens have no elevated tube margins, and exhibit interstitial spaces with open cells; but this is only owing to an imperfect state of preservation, or the effect of detrition. Surface raised in obtuse unequal monticules, with cellulose maculæ in the center." (Rominger, *loc. cit.*)

Spergen Hill, Paynter's Hill and Lanesville, Indiana, very abundant; Bedford, Indiana, common.

Indiana University collection.

FISTULIPORA SPERGENENSIS var. MINOR n. var.

Plate XXXVI, fig. 4.

This form, of which one specimen has been seen, is associated with *F. Spergenensis* in the Spergen Hill material. It has more zoœcia to the cm. and very prominent erect hoods to the zoœcia. The specimen represents a young colony, and its peculiar characters may be due to immaturity.

Spergen Hill, Indiana, very rare.

Indiana University collection.

Genus GLYPTOPORA Ulrich.

Jour. Cincinnati Soc. Nat. Hist., vol. VII, p. 39.

"Zoaria forming thin, leaf-like expansions, composed of two subequal layers of cells, adhering to each other back to back. Both surfaces celluliferous, with an elevated, sharp midrib, or ridge, which may simply divide dichotomously at varying intervals, or inosculate more or less frequently, so as to leave irregular, cup-shaped depressions. The sharp margin of this ridge is non-poriferous, and may be either straight or serrated. Distributed with some regularity over the depressed portions of the two surfaces are sharply defined, more or less elongated, depressed maculæ or furrows, which may bifurcate once or twice. The remaining portions of the surface are uniformly occupied by the zoœcial apertures, which, as usual, are provided with a small crescentic lip. Inter-zoœcial spaces occupied by vesicular cells, which are filled and quite obliterated, in the 'matured' regions, by a secondary deposit." (Ulrich, *loc. cit.*)

GLYPTOPORA MICHELINEA (Prout).

Plate XXXVI, fig. 1.

Trans. St. Louis Acad. Sci., I, p. 573.

"Zoarium encrusting or free, with a wrinkled epitheca on the lower side. Upper surface divided into larger or smaller, deep, polygonal, cup-shaped cavities, enclosed by prominently elevated, sharp ridges, the summits of which, when in a good state of preservation, are serrated. The cups vary greatly in size, but are approximately equal on each example. The average width in the two largest specimens seen is about 12 mm., while in others it is only about 9 mm. At the bottom of the cups there is a more or less elongated depressed solid macula. Similar narrow maculæ extend up the sides of the ridge at intervals apart of 2 mm., more or less. These maculæ usually occupy corresponding positions on each side of the ridges, and being depressed, terminate before reaching their summits. The serrated character of the comb of the ridge is due to this circumstance. The spaces between the maculæ is [are] uniformly occupied by the zoœcia apertures. These are sub-circular, about 0.16 mm. in diameter and 9 in 3 mm., separated by interspaces equal in width to their diameter." (Ulrich, Geol. Surv. Ill., VIII, p. 515.)

Bedford, Indiana, very rare.

Indiana University collection.

Normal range Warsaw.

Genus STENOPORA Lonsdale.

Darwin's "Volcanic Islands," Appendix, p. 161.

"Zoarium ramose, sublobate, massive, laminar or parasitic. Surface even or montiferous. In the mature region the zoœcial tube walls are periodically thickened so as to appear moniliform in vertical sections. Comparatively large acanthopores are developed at the angles of the cells. Diaphragms straight, more or less numerous, with a large central perforation; a few irregular mesopores occasionally present." (Ulrich, Geol. Surv. Ill., VIII, p. 375.)

STENOPORA SP?

Plate XXXVI, fig. 2.

Zoarium a thin crust-like expansion with a wrinkled epitheca on the reverse. Zoœcia very short, arising abruptly from the epitheca, rounded or irregularly polygonal, 0.2 mm. in diameter, 17 in 0.5 cm. Between the zoœcia there are occasional mesopores, especially at the interzoœcial angles. Interzoœcial walls thin, nodose when perfect (probably due to the acanthopores). An occasional perforated diaphragm may be seen in the apertures of the zoœcia. The internal characters of this species are not very fully known, on account of the lack of material. The zoœcial walls are periodically thickened, and acanthopores are small and numerous, which characters are, together with the perforated diaphragms, sufficien tto place the form in the genus *Stenopora.*

Bedford, Indiana, very rare.

Indiana University collection.

STENOPORA RUDIS Ulr.

Plate XXXVI, fig. 3.

Zoarium a circular, disc-like body, 10 mm. in diameter, with a concentrically wrinkled epitheca, with faint radial striations. Zoœcia usually pentagonal to square, but sometimes rounded, 0.25 to 0.3 mm. in diameter, about 14 to the half cm.; when well preserved a centrally perforated diaphragm may be seen in the zoœcia, depressed somewhat below its mouth. The ridges between the zoœcia are about 0.1 mm. thick and without nodes or spines except an occasional node at the angles. The material available has not made it possible to elucidate satisfactorily the internal structure. In tangential sections the walls appear rather thin, with a dark median lamina, and with an occasional obscure acanthopore at the angles. According to Mr. Bassler, this is a young specimen of *S. rudis.*

Bedford, Indiana, very rare.

Indiana University collection.

In Kindle's list of the fossils of Indiana (22d Ann. Rept. Indiana Geol. and Nat. Hist.), the following species of Bryozoa not described in the present paper are listed from the "Warsaw and St.

Louis" limestones, namely: *Archimedes laxus* (Hall), *A. Meekanus* (Hall), *A. Owenanus* (Hall), *A. reversa* (Hall), *A. wortheni* (Hall), and *A. Swallowanus* (Hall); all these are from beds higher than the Salem limestone; *Coscinium asterium* Prout, (*Fistulipora asteria*), *Coscinium elegans* Prout (*Glyptopora elegans*), *Coscinium escharense* Prout (not recognizable), *Coscinium escharoides Prout* (not recognizable), *Coscinium Keyserlingi* Prout (*Glyptopora Keyserlingi*), *Coscinium tuberculatum* Prout (*Fistulipora? tuberculata*) *Coscinium Wortheni* Prout (not recognizable); (I have not seen specimens of any of these species in the material at my disposal); *Cyclopora discoidea* Prout (*Proutella discoidea*), (not seen); *Hemitrypa plumosa* (Prout) (this probably occurs at Spergen Hill and Lanesville); *Paleschara tuberculata* Prout (*Stenopora tuberculata*) (probably occurs in the Salem limestone; several specimens in the university collection may belong to this species); *Polypora Halliana* Prout (not seen); *Prismopora* [?] *serrata* (Meek) (occurs in higher formations); *Synocladia biserialis* Swallow (*Septopora biserialis*) (occurs in the Coal Measures).

BRACHIOPODA.

BY J. W. BEEDE.

ORTHOTHETES MINUTUS Cumings.

Plate XVIII, figs. 1-16; Plate XX, fig. 7.

Orthothetes minutus Cumings, Amer. Geol. Mch., 1901, p. 147, pl. 15.

"Shell semi-ovate to subquadrate in old individuals; hinge-line usually less than the greatest width of the shell, especially in young individuals; cardinal extremities forming an obtuse, or sometimes a right angle with the lateral margins. Surface finely plicated; plications increasing toward the margins by interstitial implantation. Crests of the plications crenulated by numerous equally spaced fine concentric lines.

"Ventral valve concave, with a pronounced tendency to irregular growth about the beak. In mature individuals the beak becomes strongly retrorse and greatly elevated, equaling in height one-half the length of the shell. Area well defined, flat, showing in well preserved specimens a low ridge on each side of the prominent deltidium and parallel with its margins. The younger specimens sometimes show a perforation of the apex of the deltidium.

"Dorsal valve regularly convex, greatest elevation about one-third of the way from the beak to the front margin, though there is considerable variation in this respect in individuals of different age. Usually some flattening at the cardinal extremities. Area very narrow or scarcely at all conspicuous.

"Interior of ventral valve showing rather prominent teeth, which diverge widely. Cardinal process in the dorsal valve elevated, projecting somewhat beyond the hinge-line; notch shallow, the grooves on the posterior faces of the apophyses very faint.

"Ratio of breadth to length of an average adult individual about as eleven to eight.

"Observation.—This form can not be referred to the *O.* (*Terebratulites*) *umbraculum* of Schlotheim,* from which it differs in

*Schlotheim, Petrefk, I. 256. II, 67; Schnurr, Brachiop. Der Eifel, 216. t. 38, fig. 2; t. 44, fig. 4; Bronn Lethæa, Geog. I, 361.

the less length of the hinge-line, fewer plications, greater proportionate elevation of the ventral beak, which in the present species becomes strongly retrorse, and the subquadrate rather than semicircular outline of the shell. The figures of Schlotheim's species also show a strongly quadrilobate cardinal process, while in the present species the notch is very shallow and the grooves are very faint. The species to some extent resmble *O. lens,* from which it differs in the form of the cardinal process and the greater proportionate length of the latter species.

"Development.—In the search for specimens of this rather rare species (about fifty specimens were found among several thousand of the commoner Spergen Hill forms) a number of very young stages were obtained. While even the adult individuals share in the general stunting so characteristic of the entire Spergen Hill fauna no complete specimen in the writer's collection having a length of more than 5 mm., nevertheless these larger individuals present the usual features of maturity.

"The smallest individual observed has a length of 0.6 mm. and a breadth of 0.9 mm. In this specimen the ventral valve is roughly conical in shape, though slightly more convex toward the beak, which projects conspicuously beyond the hinge-line and is very prominent. The surface shows eighteen plications at the margin, as against forty in the largest individual observed, while the posterior third of the shell is without ornamentation except a few obscure concentric markings. The area is high and the large deltidium less sharply marked off from it than in the older individuals. The breadth at the hinge is conspicuously less than farther forward.

"The dorsal valve has its greatest convexity at the center and is also smooth for a considerable distance from the beak. It shows no sign of an area.

"Individuals of the length of 2 mm. have the area perpendicular to the plane of separation of the valves, and the ventral valve showing a slight convexity toward the front. The number of plications has increased from 18 to 22 or 23, and the region of greatest convexity in the dorsal valve has approached somewhat the beak. The youngest individual shows a marked conformity to the generalized type of brachiopod, as was found by Beecher and

Clark to be the case in the species of the Waldron fauna."* (Cumings.)

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Lanesville.

Specimens of this species occur having a width of about two inches. The beak of the pedicle valve is variable, and usually high in old individuals, and the valve is usually heavily wrinkled. In specimens of a centimeter or thereabouts in diameter the brachial valve is very convex in longitudinal outline.

PRODUCTUS BISERIATUS Hall.

Plate XXII, figs. 8-12; Plate XIX, fig. 6.

Productus biseriatus Hall, Trans. Alb. Inst., IV, p. 12, 1858.

"Shell longitudinally ovate; pedicle valve extremely gibbous, without sinus, arcuate, marked by five or six elevated distant concentric undulations which are ornamented upon their dorsal margins by a single row of elongate pustules or nodes; and on their middle and basal margins by numerous smaller granulations; beak attenuate and extremely arcuate; brachial valve semi-oval, flattened near the base, having the greatest concavity near the beak, which is obtuse; surface of the brachial valve marked by eight or nine closely arranged, concentric bands, which are marked by granulations, as in the pedicle valve; hinge-line scarcely so wide as the greatest width of the shell; extremities rounded." (Hall, slightly emended.)

Localities.—Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville.

"The specimens of this species present all the features of *P. vittatus,* Hall * * * but dwarfed. The smaller individuals are so closely similar to the form known as *P. alternatus,* Norwood and Pratten, 1854, which is perhaps not distinct from *P. vittatus.* There are great variations among the specimens usually included under the name *P. vittatus* and the passage from the one to the other extreme, as marked by the three forms, is so gradual that it is doubtful if they should not all be included under the one name of *P. alternatus.*" (Whitfield.)

*Memoirs of the New York State Museum, Vol. I, No. 1.

I am unable to find any differences of moment between this species and *P. alternatus,* but without the material of the latter species at hand it would be presumptuous for me to say that they are identical. Well preserved material shows the "granulations" of Hall to be the bases of very long, slender spines, which are sometimes so thick and long as to hide the shell.

PRODUCTUS INDIANENSIS Hall.

Plate XXII, figs. 6-7; Plate XIX, figs. 7-7a.

Productus indianensis Hall, Trans. Alb. Inst., IV, p. 13, 1858.

"Shell sub-ovate, gibbous, inflated; pedicle valve without sinus, gradually contracted towards the beak, which is large and strongly arcuate, obtuse at the extremity and very gibbous below; surface pustulose or aculeate, marked by extremely fine, concentric striae, and a few irregular undulations; pustules or bases of spines irregularly distributed over the surface of the shell, with a linear series down each side below the hinge extremity; hinge-line apparently less than the width of the shell." (Hall, slightly emended.)

Localities.—Lanesville, Spergen Hill, Bedford, Harrodsburg, Bloomington, Paynters Hill.

"It is extremely difficult to point out the differences between this and the preceding species. The specimens are a little more ventricose on the umbo of the ventral valve than those of *P. biseriatus,* while the entire shell is more rotund. The surface marking, what little there is left on the specimens, is of the same character precisely as on that one, so the specific distinction will have to rest entirely on the external form. I have seen interiors of dorsal valves of this form which have a thickened border very distinctly marked, and which have not shown any evidence of concentric undulations. But there are none in the collection that can be figured." (Whitfield.)

If the material in hand is what Hall referred to this species, as it appears to be, it is certainly distinct from *P. biseriatus.* As Whitfield points out, the entire shell is more rotund, and corresponding with this the brachial valve is very much more concave than that of *P. biseriatus.* Whitfield's figures hardly bear out his statements concerning the surface markings of the two. The first two millimeters of the shell of *P. biseriatus* from the point of

the beak are identical in appearance and markings with the entire shell (so far as observed) of *P. indianensis,* viz., having rows of single spines of uniform size *without having the shell divided into sharply marked zones.* After passing two or two and a half millimeters from the tip of the beak the concentric zoned area sets in abruptly, and with it the double series of large and small spines. The small spines have not been observed on specimens of *P. indianensis,* nor do the zonal marks appear on either valve. These characters have been observed on specimens a centimeter in length, the largest seen of this species. Spines have been observed on the brachial valve of this species similar to those of the other valve. On the *P. biseriatus* they have been seen nearly as long as the specimen itself.

The distinction in the general appearance of well preserved specimens is sufficient enough for students to differentiate them in the field. One student compared *P. indianensis* with its spines to a "wild cucumber," a remark that is very suggestive when the spines of the fossil are preserved.

PRODUCTUS BURLINGTONENSIS Hall, Var.

Plate XVII A, figs. 1-1c, 4-4a; Plate XX, figs. 1-1c.

Productus flemmingi var. *burlingtonensis* Hall, Geol. Rep. Iowa, I, Pt. II, p. 598, pl. XII, ff. 3a-g, 1858.

"Shell of medium size or larger, longer than wide, sometimes the length and breadth equal: hinge-line less than the width of the shell below; cardinal extremities auriculate, ventral valve extremely ventricose, recurved, bringing the beak opposite or below the center of the valve, and nearer the base than the width of the hinge-line; marked by a central longitudinal sinus, which is more or less strongly defined, and reaches from near the beak to the base. Dorsal valve moderately concave, and sometimes nearly flat in the upper part and abruptly curved or geniculate in the middle, the lower portion being rectangular to the upper; sometimes a slight elevation along the center of the lower part.

"Surface of the ventral valve marked by regular rounded radiating ribs, which bifurcate a few times, the bifurcations occurring almost wholly above the center of the shell; transversely marked

by fine concentric striae, and some strong wrinkles on the upper part of the valve, and a few inconspicuous undulations upon the middle of the shell. Scattered, rounded, tubular spines occur on the middle and lower part of the shell at the coalescing of the ribs and rarely a row near the base, with smaller ones sometimes at the base of the ears and toward the hinge-line.

"Interior of the dorsal valve showing a bifurcate cardinal process, each branch of which appears to be slightly bilobed at the extremity, proceeding from a thickened interior cardinal margin and connected with a short median ridge; the reniform vascular areas widely separated." (Hall.)

Localities.—Spergen Hill.

Our specimens from the base of the Salem limestone at Spergen Hill are so similar to those of this species as figured by Hall and Clarke that there seems no doubt of their close relationship to this species, though this species has not been recorded from so recent a horizon before. They are intermediate in form between *P. burlingtonensis* and *P. marginicinctus* and *P. wortheni,* which are probably identical. The species here described may be a variety of *P. burlingtonensis.* They are abundant in places in the Harrodsburg limestone below.

PRODUCTUS GALLATINENSIS Girty.

Plate XVIIA, figs. 2-2a, 3-3e.

Productus gallatinensis Girty, U. S. Geol. Surv. Mon. XXXII, pt. II, p. 533, Pl. LXVIII, ff. 7a-c, 11-11d, 1899.

Shell small, very arcuate, plump. Beak prominent, strongly recurved and produced. Ears not well shown, but somewhat convex and extending out as far as the shell in front; wrinkled and somewhat spinous; separated rather distinctly from the body of the shell. Pedicle valve large, very gibbous, without distinct sinus and rapidly inflating from the beak; in old individuals the margin is produced well below the level of the hinge-line. The entire valve has a very plump, ventricose appearance. The visceral portion, particularly the posterior part of it, is pretty regularly marked by concentric wrinkles which disappear on the upper anterior portions of the shell. The valve is also marked by rather fine radiating costae, about 56 to the inch. Like most of

the striated species of the genus the ribs bifurcate on the visceral region and coalesce to a greater or less degree on the front. The anterior surface has a few coarse spines. The brachial valve is quite concave near the beak, flattening, but still remaining concave, to the margin of the visceral region, where it bends abruptly downward. Surface marked as in the other valve except, perhaps, for the spines.

The relative dimensions of this species correspond with those of *P. gallatinensis* Girty, and, judging by his figures, the surface marks are almost identical as is the appearance and curvature of the shell. They are of the same size and are probably specifically identical.

This shell is strikingly like *Productella arcuata* Hall, but is a true *Productus*.

The difference between *P. gallatinensis* as figured by Girty and *P. parvus* M. and W., is rather slight to be considered of specific value in this genus. I should not be surprised if, after all the intermediate forms have been worked out, and the rocks thoroughly collected from, *P. gallatinensis* and *P. parviformis* Girty, were classed under *P. parvus* M. and W.

Localities.—Spergen Hill.

At Spergen Hill this species is characteristic of the base of the stratum.

RHIPIDOMELLA DUBIA Hall.

Plate XXII, figs. 1-4.

Orthis dubia Hall, Trans. Alb. Inst., IV, p. 12, 1856.

"Shell circular, or oval-ovate; valves nearly equally convex, the brachial valve somewhat more rotund; pedicle valve flattened in the middle, with broad depression extending thence to the front of the shell, giving it a sinuous outline; beak of the pedicle valve extended beyond the opposite valve, slightly incurved, with a triangular foramen; area very small, and (with the foramen of the pedicle valve) nearly covered by the beak of the brachial valve, which curves toward the opposite valve, bringing the two almost in contact at their margins. Surface marked by fine, rounded, closely arranged striae, which increase by bifurcation and implantation; the striae down the mesial depression are distinctly tubu-

lar, with minute, pore-like openings at intervals, directed downwards. These are probably the bases of minute tubular spines, which were closely imbricated. Minute pore-like openings are sometimes seen on other parts of the shell, but never so conspicuous as in the pedicle sinus." (Hall, slightly emended.)

Localities.—Lanesville, Paynters Hill, Spergen Hill, Harrodsburg, Bloomington.

"This species is more nearly allied to *Orthis theimei* White, from the sandstones below the Burlington limestones at Burlington, Iowa, than to any other one. It differs, however, in the more pointed beak and rapidly sloping cardinal margins, in its narrower form and less regularly convex dorsal valve. The species is also remarkable for the thickening of the valves in older specimens, especially of the ventral valve. Subsequent collections have shown it to attain a considerably greater size than that given under the original description; specimens from Paynters Hill measure five-eighths of an inch in length. In such examples the striae become very much elevated and exsert, and the shell remarkably thickened."

CAMAROPHORIA SUBCUNEATA Hall.

Plate XXII, figs. 47-49.

Rhynchonella subcuneata Hall, Trans. Alb. Inst., IV, p. 11, 1856.

"Triangular, subcuneate; front rounded, meeting the lateral slopes at an obtuse angle; sides sloping to the beak and meeting at an angle of 60 or 65 degrees; valves nearly equally convex, pedicle valve most convex towards the beak; beak of pedicle valve very acute, scarcely incurved, and perforate by a triangular foramen; beak of brachial valve acute, closely incurved below the triangular foramen. Surface marked by about twelve to fourteen (and rarely sixteen) strong, simple, angular plications, which are somewhat obsolete near the beak; scarcely any indication of a sinus; plications crossed by fine concentric striae, and in old shells at irregular distances, by stronger imbricating folds or wrinkles parallel with the lines of growth; sides of both valves beneath the beak free from plications, and forming a very distinct elongate-oval space. Length, .16 to .41; width, .15 to .39 of an inch." (Hall, slightly emended.)

Localities.—Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Paynters Hill, Lanesville.

CAMAROPHORIA WORTHENI Hall.

Plate XXII, figs. 35-39.

Rhynchonella wortheni Hall, Trans. Alb. Inst., IV, p. 11, 1858.

"Shell small, longitudinally sub-trigonal, very abruptly tapering to the apex; brachial valve very convex or gibbous towards the front; pedicle valve nearly flat and broadly sinuate in front, with a single broad, flattened plication, commencing near the margin, and filling a deep sinus in the opposite valve, corresponding to two short, rounded plications on the front of the brachial valve; edges of the shell on each side of the mesial sinus sharply undulated, with distinct marginal folds; beak of pedicle valve pointed, straight, with triangular foramen. Surface marked by fine concentric striae, and some faint remains of finer radiating striae. Length .22, width .24 of an inch." (Hall, slightly emended.)

Locality.—Alton, Ill.

PUGNAX GROSVENORI Hall.

Plate XXII, figs. 31-34.

Rhynchonella grosvenori Hall, Trans. Alb. Inst., IV, p. 10, 1858.

"Shell globose or subtriangular, rotund or depressed; brachial valve more convex than the other, greatest convexity of the two valves near the front, sloping abruptly towards the beak, where the two sides meet at nearly a right angle; beak rather small, neatly defined, nearly straight or slightly incurved, with a linear or a subtriangular foramen; beak of opposite valve round and obtuse, closely incurved. Surface marked by from 14 to 18 distinct, rounded, simple plications, which often become obsolete towards the beaks; four or five of the folds depressed, forming a sinus on the larger valve, with a corresponding elevation of five or six plications on the opposite valve. Length .14 to .22, width .13 to .23 of an inch." (Hall, slightly emended.)

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Lanesville, Stinesville, Ellettsville.

"The nearly globular or depressed globular form will readily distinguish this from any lower Carboniferous species of the genus." (Whitfield.)

PUGNAX MUTATA Hall.

Plate XXII, figs. 43-45.

Rhynchonella mutata Hall, Trans. Alb. Inst., IV, p. 10, 1858.

"Shell subtrigonal, more or less gibbous, front broadly rounded or nearly straight, abruptly tapering to the apex, the two sides meeting at an angle of nearly 90 degrees; brachial valve much more convex than the opposite one, which is often depressed, shell most convex near the anterior margin; beak of pedicle valve nearly straight or but slightly incurved; foramen triangular; beak of the opposite valve obtusely angular and closely incurved against the pedicle valve. Surface marked by from 12 to 16 strong, subangular plications, about four or five of which are depressed in the sinus of the pedicle valve; sinus not deeply impressed on the margin of the shell; concentric striae rarely visible. Length .15 to .30, width .14 to .32 of an inch." (Hall, slightly emended.)

Locality.—Alton, Ill., Warsaw, Ill.

This species may be distinguished from Camarophoria subcuneata, which it resembles, by its shorter and broader form.

PUGNAX? QUADRIROSTRIS N. SP.

Plate XIX, figs. 4-4c.

Shell very small, quadrangular in outline; beaks not prominent; shell widest near the center. Pedicle valve crescent-shaped, more convex near the beak; deeply sinuate most of its length, the lateral edges in the central portion are elevated into angulated points. The valve sometimes has an impressed line along the sinus. The anterior margin is prolonged into a very pronounced linguate extension. Pedicle opening nearly closed by the opposite valve; form of the opening unknown. The brachial valve is smaller than the other, the beak is nearly as prominent. The valve is convex at the beak and concave the remainder of the distance to the front; transversely very convex in the central part between the lateral angles. The surface is ornamented by about three or four very faint radiating costae on each side of the valves, and by faint growth marks.

Localities.—Harrodsburg, Stinesville.

There are two specimens from each place. Those from the Big Creek quarry (Stinesville) are more robust than the Harrods-

burg specimens, but the latter are better preserved and show the surface ornamentation.

When these specimens are held in the hand the appearance of the anterior and posterior ends and the two lateral angles is so similar that either of the four might be taken for the beaks, at a cursory glance, and the shell is so shaped as to carry out the resemblance.

Nothing is known of the internal characters of these shells, and the generic reference is based wholly on surface expression. Their actual relationships can only be worked out when material comes to hand showing the critical characters. This species slightly resembles *Terrebratula meyendorfii* Murch., de Vern. and Keyserling, but differs in having by far the greater part of the brachial valve of concave outline instead of sharply convex. The resemblance is probably superficial. Another species which might be mentioned in this connection is *Terebratula acuminata* Martin, but this resemblance is remote.

RHYNCHONELLA MACRA Hall.

Plate XXII, figs. 40-42.

Rhynchonella macra Hall, Trans. Alb. Inst., IV, p. 11, 1858.

"Shell triangular, flattened; apex acute; valves nearly equal; dorsal valve a little more convex toward the beak, which is quite straight, extended beyond the lesser valve, and with a sub-triangular foramen, which is slightly rounded above. Surface marked by from 18 to 24 small, rounded plications, which are about equal to the spaces between. Length .15 to .24, width .14 to .29 of an inch." (Hall.)

Locality.—Alton, Ill.

"The peculiar flat form of this species will readily distinguish it from the other associated species, except from the young shells of *P. mutata*. From such specimens it will be almost impossible to separate them without leaving some question as to their identity." (Whitfield.)

RHYNCHONELLA RICINULA Hall.

Plate XXII, fig. 46.

Rhynchonella ricinula Hall, Trans. Alb. Inst., IV, p. 9, 1858.

"Shell very small, longitudinally ovate or sublenticular, neatly rounded in front; valves almost equally convex; beak of pedicle valve straight, comparatively much extended, perforate by a triangular foramen; surface marked by from 12 to 16 angular plications, which often terminate abruptly about one-third the distance from the base to the beak, sometimes becoming obsolete on the upper half of the shell. Length .11, width .10 of an inch." (Hall.)

Localities.—Spergen Hill, Harrodsburg.

"The minute size of this shell might readily be considered its chief specific feature, were it not that the young of other species are found in the same rock. Those of *R. macra* so nearly resemble it as to preclude any possibility of distinguishing between them, except by the adult aspect which shells of this species present. As no adult forms of *R. macra* have been found at Spergen Hill or Bloomington, however, they will give but little trouble. The very young shells of *C. subcuneata* and *P. grosvenori* are often mistaken for this one, and I can not see that there is any sure means of distinguishing between them." (Whitfield, slightly emended.)

CENTRONELLA?? CRASSICARDINALIS Whitfield.

Plate XXII, figs. 50-52.

Centronella crassicardinalis Whitfield, Bull. Amer. Mus. Nat. Hist., I, p. 55, pl. VI, ff. 50-52, 1882.

"Shell of about medium size and nearly circular outline, the length of the ventral valve being slightly greater than the width; longitudinally it is strongly arcuate or curved from beak to base, but nearly flat transversely, except near the front, where it becomes slightly sinuate. Beak of the ventral valve projecting beyond the hinge fully one-fourth the length of the valve, with the cardinal slopes very large, broad and flattened, making the extreme posterior edge of the valve rather sharply angular. Foramen small and round; deltidial opening large and triangular; teeth strong. The interior of the valve seems to have been occupied largely by the muscular scars, while the cardinal edges of the valve have been

greatly thickened, so as to present a very unusual character. Dorsal valve unknown. Surface, as indicated by the ventral valve only, marked by concentric varices of growth." * * * (Whitfield.)

Locality.—Spergen Hill.

There is very little doubt but that this shell is the same as the one described by Hall and Clarke as *Athyris densa* from this same locality and horizon. It is not referred here positively as no specimens occur in our collection of exactly the form of the type and I had no opportunity to study them. I have no doubt of their being synonymous, however. In this case the shell will be known by Hall and Clarke's specific name, as *A. crassicardinalis* is preoccupied.

DIELASMA TURGIDUM Hall.

Plate XXII, figs. 53-58; Plate XIX, figs. 5-5a.

Terabratula turgida Hall, Trans. Alb. Inst., IV, p. 6, 1858.

"Shell longitudinally ovate, often extremely gibbous, emarginate in front, pedicle valve most convex in the middle, having a sinus extending to the base of the shell; beak large, rounded and prominent, incurved and pointed, with an oval or subcircular foramen just above or in the extremity. Brachial valve most convex in the middle or near the front, with or without a short sinus, in which is sometimes a short and obscure fold. Surface marked by strong concentric lines of growth; and near the front, in some shells, are strong wrinkles or folds which distort the form of the shell. Length .16 to .32, width .13 to .27 of an inch." (Hall, slightly emended.)

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Elletsville, Stinesville; Warsaw and Alton, Ill.; Boonville, Mo.

"This is a very good miniature representative of *T. sacculus*, Sow., of the Carboniferous limestones of Europe, but although recognized at many localities in this country, it is never of such large size as is common with that species. It is very variable in its degree of ventricosity, sometimes increasing enormously in adult individuals, although they may be of small size. Some individuals have a thickness through the valves fully equal to the entire length of the shell." (Whitfield.)

DIELASMA FORMOSUM Hall.

Plate XXII, figs. 59-64.

Terebratula formosa Hall, Trans. Alb. Inst., IV, p. 6, 1858.

"Shell longitudinally oval-ovate; dorsal valve more convex in the middle and upper part; beak extended upwards, prominent, incurved; valves compressed near the front, which is neatly rounded, the margin presenting a slight undulation; sometimes sinuate in front. Surface marked by fine concentric lines of growth, and sometimes by parallel stronger folds or wrinkles. Under the magnifier the shell presents a finely punctate structure. Length .14 to .44, width .10 to .31 of an inch." (Hall.)

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Elletsville, Stinesville, Lanesville.

"This is a beautiful and generally very symmetrical species, but it varies much in form and also in size. The typical specimens were scarcely half an inch long, but among more recent collections specimens measuring about one and one-half inches have been observed." (Whitfield.)

DIELASMA GORBYI Miller.

Plate XX, fig. 5.

Terebratula gorbyi Miller, Adv. Sheets 17th Ann. Rep. Geol. Surv. Ind., p. 77, pl. XIII, ff. 3, 4, 1891. Same Rep., p. 687, pl. and fig. same, 1892.

"Shell variable in size, but growing very large; elongate-elliptical in a dorsal view; cuneate in front in a side view; valves unequally gibbous; rounded in front; sides subparallel. Shell structure beautifully punctate, under an ordinary magnifier, and the punctures may be seen with the unaided eye.

"Ventral valve more gibbous than the dorsal; arcuate from the beak to the front; greatest convexity in the middle part; beak very prominent, strongly incurved, inflated along the umbonal slopes; truncated by a very large foramen. No hinge area.

"Dorsal valve much shorter than the ventral, less gibbous, somewhat depressed, convex in the middle part; beak incurved beneath the beak of the ventral valve. No hinge area.

"This species may be distinguished by its large size, elongate-elliptical form and large foramen.

"Found by Prof. S. S. Gorby in the Keokuk Group, at Edwardsville, Indiana, and now in his collection and in the State Museum at Indianapolis. The specific name is in honor of the collector." (Miller.)

Locality. "Warsaw Group, Edwardsville, Indiana." The specimen figured was loaned by Mr. G. K. Greene.

A specimen purporting to be the type of this species, in the University of Chicago, is from, to all appearances, the Greensand of New Jersey. It will have to be admitted also that it looks suspiciously like the figure in the 17th Indiana report. The two species are sufficiently similar in appearance that it is difficult to say whether it is the shell described, or whether the mistake was complete all around. However, there can be no such mistake concerning the specimen here figured.

SPIRIFERINA NORWOODANA Hall.

Plate XXII, figs. 16-17.

Spirifer norwoodana Hall, Trans. Alb. Inst., IV, p. 7, 1858.

"Shell small, semi-elliptical, very gibbous, angles rounded; hinge line shorter than the greatest width of the shell. Pedicle valve very convex and strongly arching near the beak, which is curved over the area; plications about eight, the central ones very strong and the mesial depression distinctly continued to the beak. Brachial valve ranging from depressed convex to extremely convex, and marked by three strong plications on each side of the mesial fold, which has often a depressed line along the center towards the base, with scarcely a distinct fold in the sinus of the pedicle valve. Area small, high, not extending to the extremities of the hinge; foramen scarcely higher than wide; surface, in unworn specimens, marked by concentric, imbricating lamellae. Length .07 to .18, width .08 to .21 of an inch." (Hall, slightly emended.)

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Elletsville, Stinesville.

"The shells of this species bear the same relations to *Spiriferina spinosa,* N. and P., that those of the above species do to *S. leidevi*. except that these are rotund, in which feature they show more of an adult stage than do any of those of the other form. The shell of the best preserved specimen of this species preserves the

spinose surface, and under a strong glass faint indications of the punctate structure so distinctive of *S. spinosa* is discernible. As both *Spirifer leidevi* and *Spiriferina spinosa* occur of the normal form at three of these localities, it would be natural to suppose these dwarf specimens may bear some close relations to those species." (Whitfield.)

After careful examination of a good lot of material of normal size from Bloomington and Bedford in practically perfect state of preservation, I believe this is a valid species. The surface of *S. norwoodana* does not possess the large spines of *S. spinosa.* The pustules are all of equal size and rather highly elevated and contain the exterior openings of the punctae. In Norwood and Pratten's species from younger rocks a portion of these pustules are developed into larger spines.

There is no imperforate covering of the valves, as described by Girty for some western relatives of *S. spinosa.*

SPIRIFER SUBORBICULARIS Hall.

Plate XIX, figs. 3-3a; Plate XXI, fig. 4.

Spirifer suborbicularis Hall, Geol. Rep. Iowa, I, pt. II, p. 644, 1858.

"Shell suborbicular, length and width nearly equal, or somewhat wider than long; hinge-line much shorter than the width of the shell; cardinal extremities regularly curved. Dorsal valve convex, gibbous above the middle, with the mesial fold becoming defined below the beak, and somewhat prominent at the base. Ventral valve convex, gibbous above the middle, with elevated umbo and beak abruptly incurved over a narrow area, which in length is about equal to half the width of the shell; foramen with the dental lamellae projecting, and partially closed by a pseudo-deltidium."

"Surface marked by broad, flattened, scarcely defined plications, of which there are seven or eight on each side of the mesial fold and sinus, with two or three more faintly defined on these parts of the shell, and some appearance of a smaller plication in the center of the sinus.

"This species has usually been referred to *S. pinguis;* but it differs in being more orbicular, and having a proportionately more

extended hinge-line, as well as the extremely flattened plications, by which it may be distinguished from all other species which have fallen under my observation from the Carboniferous rocks." (Hall.)

The pedicle valve is characterized by fairly strong teeth, supporting high, long, thick dental lamellae, which extend nearly a third the distance to the front of the shell, or two-thirds the distance to the front end of the muscular scars. Area of scars subelliptical or paddle-shaped, the small ridges radiating, more or less, from the central line, which may be rough, but is not elevated into a septum. The relative length of the hinge varies very greatly in different individuals, being anywhere from scarcely one-third to a half the width of the shell.

Localities.—Lanesville, Bedford.

SPIRIFER SUBCARDIIFORMIS Hall.

Plate XXI, figs. 2-2b.

Spirifer subcardiiformis Hall, Geol. Rep. Iowa, I, pt. II, p. 660, 1858.

"Shell sub-elliptical in marginal outline, a little wider than long; hinge-line shorter than the greatest width of the shell. Dorsal valve a little less convex than the ventral, its beak somewhat prominent and projecting beyond the hinge-line; mesial fold rather broad in front, slightly elevated, marked by four plications, which all coalesce at the beak; a very slight elevation appears in the bottom of the groove which separates the two middle plications of the fold, and the two grooves which separate the fold from the lateral portions of the valve are broader than any of the others; from seven to nine simple, rounded plications mark the space on each side of the fold, the inner ones being strong and the outer ones becoming obsolete. Ventral valve having its beak prominent, incurved and projecting back further than that of the dorsal valve; mesial sinus broad, not deep, bearing three plications; from seven to ten plications on each side of the mesial sinus, which correspond in character with those on the other valve; the posterolateral portions of the valve rounded into the area, which is very short and its limits ill-defined; foramen moderately large, triangular, and nearly equilateral.

"Length from ventral beak to front 28 millimeters; greatest breadth 32 millimeters; greatest thickness, both valves together, 18 millimeters.

"This species was originally described from an imperfect example which was obtained from the Warsaw limestone near Alton, Ill. Among a collection of fossils obtained by Mr. William Gurley, from equivalent strata at Spergen Hill, Indiana, is a more perfect example, which has served as the basis for the description and illustrations herein given." (White.)

Localities.—Spergen Hill, Bedford.

So far as I have observed these fossils are confined to the base of the stratum, and are most abundant near the north end of the cut at Spergen Hill.

SPIRIFER LATERALIS DELICATUS Rowley, var.

Plate XX, figs. 3-3a.

Spirifer lateralis var. *delicatus* Rowley, Cont. Ind. Pal. I, p. 68, pl. XXIII, ff. 21-23, 1901.

"The several specimens of this shell differ from Hall's figures and descriptions of *Spirifer lateralis*. They are much smaller and have very much finer plications, sharper in outline. The differences are hardly more than of varietal significance, however."

"The figured specimens were collected from the Warsaw limestone at Lanesville, Indiana, and form a part of the collection of Mr. G. K. Greene." (Rowley.)

I have not seen these specimens.

SPIRIFER BIFURCATUS Hall.

Plate XXII, figs. 13-15.

Spirifer bifurcatus Hall, Trans. Alb. Inst., IV, p. 8, 1868.

"Shell semi-elliptical in general form; pedicle valve gibbous; brachial valve depressed convex; plications seven or eight, which appear to coalesce towards the cardinal margin; mesial fold with a defined depression in the center, reaching half way to the beak; surface longitudinally striated and concentrically marked by fine lines. Length .09, width .11 inch." (Hall, slightly emended.)

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Elletsville, Stinesville, Romona.

"The individuals of this species in the original collection are extremely minute, and bear evidence of immaturity. Among the later collections are a number of larger specimens and others of intermediate sizes, showing a tendency to greater development in the length of the hinge-line and angularity of the plications. The larger specimens present exactly the features of partially grown specimens of *Spirifera leidyi,* N. and P., from the Chester limestones; and from this direction in the development by increased growth leave no doubt of these being dwarfed individuals of that species. A comparison of the three figures given, taking into consideration that they are enlarged six, three and two diameters, respectively, will show this development of features." (Whitfield.)

This species differs from *S. leidcyi* in never having but a single sharp rib in the sinus and two on the fold, while the typical specimens of that species have one large rib and two accessory ones in the sinus. Norwood and Pratten's species was described from the Chester beds. This would indicate that the addition of the accessory plications in the sinus took place at a later time than represented by the Salem limestone.

There are specimens from Lanesville preserved in chert (resembling the chert of the Mitchell limestone) that show the characters of S. leideyi. However, these were taken from residual clay and chert fragments from hillsides, and the horizon can not be depended on with absolute certainty, and any particular specimen may have come down from the rocks above. These remarks apply to much of the Lanesville material.

SPIRIFER HORIZONTALIS Rowley.

Plate XX, figs. 2-2a.

Spirifer horizontalis Rowley, Cont. Ind. Pal. I, p. 67, pl. XXIII, ff. 13-15, 36, 1901.

"Valves unequal in length, the pedicle being quite one-third longer than the brachial. The greatest convexity in either valve is nearer the anterior than the posterior part of the shell, and the greatest thickness at the middle of the pedicle valve.

"A slight depression traverses the mesial fold, making it appear to be a double plication. Ten simple plications on either side of the mesial fold.

"A very distinct elevation down the middle of the sinus. Ten plications on either side of the sinus.

"The shell is crossed with crowded lamellose lines of growth. Cardinal extremities pointed but not acute. Cardinal area the greatest width of the shell and forms a low, broad triangle, confined entirely to the pedicle valve.

"The horizontal position of the cardinal area where the shell rests on the middle of either valve, is the chief character of this little brachiopod. The character is constant, being shown by all the specimens before us, three double and two separate valves.

"The flattening of the pedicle valve immediately over the cardinal area is due to this character.

"This species was collected from the Warsaw limestone at Lanesville, Indiana, and now in the collection of Mr. G. K. Greene." (Rowley.)

I have seen no specimens of this species.

SPIRIFER SUBÆQUALIS Hall.

Plate XX, figs. 4-4b; Plate XXI, figs. 3-3b.

Spirifer subæqualis Hall, Geol. Rep. Iowa I, pt. II, p. 663, pl. XXIII, ff. 9a-c, 1858.

"Shell semi-elliptical, about twice as wide as long; valves almost entirely equal, the beak of the ventral valve being very slightly elevated above the opposite. Dorsal valve depressed convex; the mesial fold obtusely angular, scarcely defined at its margins: a narrow cardinal area, which is conspicuous in well preserved specimens. Ventral valve somewhat gibbous on the umbo: beak slightly incurved: mesial sinus not observable on the upper half of the shell, and becoming a broad depression with undefined margins below: area of moderate width extending to the cardinal extremities; foramen large, the width of the base greater than the length of the side.

"Entire surface, including the sinus and fold, marked by simple rounded plications, which bifurcate near the beak, and of which there are about 18 on each side, and about 8 on the mesial fold and 10 in the sinus; concentrically marked by undulating laminae of growth and finer striae." (Hall.)

Locality.—Lanesville.

The number of plications on the valves of Hall's figures, cited above, is in excess of the statement in the description. Our specimen agrees very well with the figures, but is a larger, longer-hinged specimen, with a correspondingly larger number of ribs. The hinge extremities are also more pointed.

RETICULARIA PSEUDOLINEATA Hall?

Plate XXI, fig. 5; Plate XX, figs. 6-6a.

Spirifer pesudolineatus Hall, Geol. Iowa, I, pt. II, p. 645, pl. XX, f. 4, 1858.

Hall's original description of this species is: "Shell transversely elliptical, length about three-fourths as great as the width, the sides symmetrically rounded: valves about equally gibbous. Dorsal valve with the beak a little elevated above the hinge-line and incurved, marked by rounded, undefined mesial fold which is often scarcely visible above the middle of the shell, and moderately conspicuous on the lower half: lateral portions of the valve regularly curving to the margin. Ventral valve more gibbous above the middle; mesial sinus shallow, rounded, becoming more defined below, and rarely extending to the beak, which is prominent, attenuated and incurved over the area: area of moderate height, much shorter than the width of the shell, vertically striated, well defined at its junction with the exterior of the shell, which curves inwards, occupying a portion of the space.

"Surface marked by more or less regular concentric lamellose folds or wrinkles and radiating striae, extending into long bristle-form spines from the edges of the folds, which are strongly punctate when the shell is partially exfoliated; and when still farther exfoliated, the entire surface is strongly striated."

It should be added that the spines of this species are long, double-barreled and have barbules along their sides. The species was described from the Keokuk limestone.

Localities.—Bedford, Bloomington.

Our specimens differ from the typical form of the species. Some of those from Bedford and Bloomington are intermediate in form between this species and *R. setigerus* Hall, while those from Lanesville are typical specimens of the latter species. Those from

Spergen Hill may be either so far as the fragmentary material is concerned.

No measurements are given with Hall, or Hall and Clarke's descriptions. Their figures, however, give the following proportions of length into breadth: *R. setigerus* 1.1 and 1.16, average 1.13. For *R. pseudolineatus* 1.3 and 1.25, average 1.27. The specimens from Bedford give 1.24, 1.16, 1.157, average 1.189, or approximately 1.19. A specimen broken in half from the "St. Louis Limestone, Lanesville, Indiana," has the proportion of 1.1, or the typical *setigerus* form. In other respects it is like the typical *R. setigerus* Hall. In this specimen the relation of the height of the beak to the length of the shell is 4.83; into the width is 5.17. In the large specimen from Bedford, already mentioned, these same relations are 6 and 5.5, respectively, showing the height of the beak to be much less in proportion to the other dimensions than in *R. setigerus.* It might be stated here for comparison that a specimen from the Harrodsburg limestone, below the Salem limestone, and ordinarily referred to the "Keokuk," gave 1.32 as the relation of the length to breadth.

From these comparisons it will be seen that the specimens from this horizon are intermediate in form between the two species, as is the horizon from which they are taken. I believe that the specimens from the Salem limestone at Bloomington and Bedford appear more like *R. pseudolineatus* than *R. setigerus*, and they are provisionally classed with that species, while the Lanesvile specimens are referred to the latter species. It is probable that when very large numbers of specimens are collected from this horizon they will show nearly all the variations from the one species to the other.

RETICULARIA SETIGERUS Hall.

Plate XXI, figs. 1-1a.

Spirifer setigerus Hall, Geol. Rep. Iowa, I, pt. II, p. 705, pl. XXVII, ff. 4a, b, 1858.

"Shell depressed orbicular, gibbous on the umbones: cardinal line shorter than the width of the shell below. Dorsal valve broadly elliptical, elevated in the middle by an undefined mesial fold, prominent on the lower half of the shell, becoming obsolete before reaching the beak; beak incurved, with a broad foramen

below and distinctly defined area, which is sharply limited by the exterior shell. Pedicle valve a little more convex on the umbones than the brachial valve: mesial sinus reaching the beak in a narrow depression, which becomes deeply marked below the middle of the shell; umbo prominent, rounded, with the beak curving over the foramen; area high, short, contracted by the encroaching of the exterior shell, which curves inward along the margins, vertically striated: foramen large, wider at base than the length of the side." (Hall, slightly emended.)

Localities.—Lanesville, Bedford. See discussion of previous species.

EUMETRIA MARCEYI Shumard.

Plate XXII, figs. 28-30.

Terebratula serpentaria Owen, Geol. Rep. Wis., Ia. and Minn., tab. 3a, f. 13, 1852. (Not deKoninck.)

Terebratula marceyi Shumard, Marcy's Exp. Red Riv., p. 177, pl. I, ff. 4a, b, 1854.

"Shell longitudinally ovate; valves almost equally convex; dorsal (ventral) valve most prominent near the beak, which is elevated and incurved so as to bring the circular foramen nearly on a line with the margins and valves; foramen round; ventral (dorsal) valve smaller, auriculated on the cardinal angles, beak small, scarcely rising above the straight cardinal margin; area small, triangular, not entirely confined to the larger valve, bounded by a distinct angular margin. Surface longitudinally striate, marked by fifty rounded, beautifully punctate, simple striae. Length .10 to .32, width .08 to .27 of an inch, usually. Some specimens have a length of three-fourths of an inch." (Hall.)

Localities.—Lanesville, Spergen Hill, Bedford, Bloomington, Paynters Hill, Harrodsburg, Stinesville, Romona.

"There is a very strong resemblance between the larger individuals of this species and specimens of Eumetria (Retzia) vera, Hall (Geol. Rept. Iowa, 1858, p. 704, pl. 27, fig. 3), but the latter species is not so ventricose, has not the beak so strongly incurved, has a larger cardinal area, and usually but not always stronger surface radii. The present form often attains a considerable size, especially those from Paynter's Hill, and sometimes become extremely ventricose." (Whitfield.)

ATHYRIS DENSA Hall and Clarke.

Plate XIX, figs. 2-2c.

Athyris densa Hall and Clarke, 13th Rep. N. Y. State Geol., p. 651, 1894.

"Shell transversely elongate, valves compressed; median fold and sinus not well developed. Pedicle valve shallow, with broad, sharply angled cardinal slopes, greatly thickened interiorly. The anterior margin is frequently extended into a linguate process at the termination of the median sinus. Brachial valve the more convex, with an indistinct, flattened and sometimes broadly grooved median fold with regular and even lateral slopes. In the interior of the valves the form of the muscular scars is normal, though there is a notable variation in the size of the adductor scars."

Localities.—Lanesville, Spergen Hill.

The "cardinal slopes" are produced by the thickening of the shell in the cardinal region. By this character this species can readily be separated from worn specimens of *Cleiothyris hirsuta*, with which it is associated, when the surface marks of the latter are removed by weathering.

This species is probably the same as was described by Whitfield as *Centronella crassicardinalis* as suggested by Schuchert. However, I can not be certain of this, as no typical specimens of the form described by Whitfield occur in our collections. From the type locality, though, twenty good specimens of *A. densa* were secured. I think the two are synonymous.

CLEIOTHYRIS HIRSUTA Hall.

Plate XXII, figs. 18-21; Plate XIX, figs. 1-1a.

Athyris hirsuta Hall, Trans. Alb. Inst., IV, p. 8, 1858.

"Shell varying in form from ovate to sub-circular; beak prominent, slightly extended, front compressed, sometimes faintly sinuate. Valves nearly equally convex, the pedicle valve most convex toward the beak; beak of pedicle valve prominent, incurved so as to bring the minute foramen nearly on a line with the margin of the shell; beak of the smaller valve closely incurved beneath the beak of the opposite valve. Surface ornamented by concentric imbricating lamellae, which give origin to successive rows of minute spines.

"The cast shows faint impressions of radiating striae, which are not visible on the external surface of the shell. A narrow impressed line is sometimes shown down the center of the cast of the pedicle valve; and a few specimens have a shallow depressed groove down the center of the shell from the beak to the base of both valves. A cast of a large individual shows about seven turns of the internal spire.

"From the foregoing description it will be seen that this species is closely related to the *Terebratula royssii* of Leveille, and to *T. planosulcata* of Phillips. It differs from the first in its small size and more ovate form, especially of the young individuals, and in never having the distinct sinus possessed by that shell; while the beaks of our shell are more prominent and the slope of each side is less concave. The volutions in the internal spire in *T. hirsuta* are not more than half the number represented in *T. royssii.* From the *T. planosulcata* it differs in its small size, in being less ventricose, especially towards the front margin, in the proportionally more prominent beaks and generally more elongate form. From the specimens examined the projecting spinose lamellae in our shell are never so much extended as in that species." (Hall, slightly emended.)

Localities—Lanesville, Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Elletsville, Stinesville, Romona, Alton, Ill.

"Specimens of this species obtained in later collections are very much larger than those originally used, some of those marked Spergen Hill measuring nearly three-fourths of an inch in diameter. Comparing these larger individuals, there is no perceptible difference between them and specimens of *Athyris sublamellosa,* Hall, from the Chester limestones. The figured specimen of the latter species, as given in the Geol. Rept. Iowa, 1858, pl. 27, fig. 1, has a very ventricose dorsal valve; this, however, is by no means a constant character, and some of the Spergen Hill examples are fully as ventricose on that side. The Chester examples also develop, in extreme large growth, a deeper sinus and fold, but this feature is not seen in specimens when of the size of the large ones from Spergen Hill. I can see no essential distinction either between these and specimens from the Keokuk limestones usually referred to *A. planosulcata,* Phillips." (Whitfield.)

In addition to these marks it should be pointed out that the range of *royssii* as now understood (see Schuchert's bibliography), includes the horizon from which *C. hirsuta* comes. The only reason why I have not included this species in the synonymy of the former is that most of my comparisons with *C. royssii* have been from figures and descriptions rather than specimens. With the specimens in hand it might be possible, though I think not, to discover some distinguishing features, as was the case with *Spirifer bifurcata* and *Spiriferina norwoodana*.

SEMINULA TRINUCLEA Hall.

Plate XXII, figs. 22-27.

Terebratula trinuclea Hall, Trans. Alb. Inst., IV, p. 7, 1856.

"Shell subpentagonal or ovate, robust; trilobate, lobes nearly equal; valves nearly equal, the pedicle one gibbous toward the beak, a sinus in the center, beginning above the middle of the valve, gradually becoming wider and deeper towards the base, in some specimens distinctly bounded by an obtusely angular ridge. Brachial valve varying from sub-circular to transversely oval and longitudinally ovate, most convex between the center and the beak, and distinctly trilobate, lobes extending about half way to the beak; the middle lobe often marked by a distinct linear depression; beak of the pedicle valve strong, rounded and incurved, truncated vertically by a distinct rounded foramen. Surface marked by fine concentric lines, which undulate with the lobes, and are extremely sinuous near the margin of the shell. Old shells are often marked by strong imbricating lamellae at unequal distances. Length .20 to .51, width .19 to .46 of an inch."

Localities.—Spergen Hill, Bloomington, Lanesville, Paynters Hill, Bedford, Elletsville, Stinesville.

A species of very variable form, the young specimens not showing the trilobate character.

PELECYPODA.

BY J. W. BEEDE.

PTERONITES SPERGENENSIS Whitfield.

Plate XXIII, fig. 1.

Pteronites spergenensis Whitfield, Bull. Amer. Mus. Nat. Hist., I, p. 56, pl. VII, f. 1, 1882.

"Shell very inequilateral and oblique. Hinge-line a little less than the length of the body of the valve, marked by a narrow, linear or cardinal ligamental area. In the left valve the anterior wing is of moderate size, elevated on the surface and rounded on the margin, separated from the body of the shell by a moderate depression; posterior wing large, pointed at the extremity, depressed on the surface so as to bring it entirely below the body of the valve; outer margin broadly sinuate. Body of the valve very ventricose, becoming almost subangular along the umbonal region. Beak large, prominent and projecting beyond the line of the hinge. Right valve unknown. Surface of the left valve marked by proportionally very strong concentric, lamellose striae, which are very regular in their distances and elevated so as to present almost the character of ridges on the body of the shell. Length of the largest specimen observed, measured along the body of the shell, about .33, height .20 of an inch."

Localities.—Spergen Hill, Bloomington, Harrodsburg.

NUCULA SHUMARDANA Hall.

Plate XXIII, figs. 2-6.

Nucula shumardana Hall, Trans. Albany Inst., IV, p. 16, 1856.

"Shell obliquely ovate or sub-cuneate, gibbous towards the beaks; beaks anterior, elevated, approximate or in contact; anterior end vertically truncate; posterior side cuneate, sloping from the beak; cardinal line forming an angle of about 80 degrees at the beak; base forming a broad curve from the anterior and posterior cardinal margins. Surface marked by regular equidistant,

sub-imbricating striae, rarely with unequal concentric folds. Hinge-line somewhat strongly crenulate; ligamentary pit distinct, triangular." (Hall.)

"Length .99 to .21, width .08 to .17 of an inch."

Localities.—Lanesville, Spergen Hill, Harrodsburg, Bloomington, Elletsville, Romona, Stinesville.

"A very pretty species, and very closely resembling *N. parva,* McChesney, from the Coal Measures, both in size and form. In form it is very constant, the figures given being of the extremes found in the collection. The surface structure offers more variety, as some individuals are very regularly marked and others are covered with strong varices, marking stages of growth. The dentition as obtained from separated valves is shown in fig. 6, pl. 7, the teeth forming rounded tubercles." (Whitfield.)

NUCULANA NASUTA Hall.

Plate XXIII, figs. 7-9.

Nucula nasuta Hall, Trans. Alb. Inst., IV, p. 17, 1858.

"Shell sub-ovate, abruptly contracted in front; posterior extremity rounded; beaks prominent, sub-central; anterior side shortest and contracted both laterally and vertically into a proboscidal extension. Surface marked by regular lines of growth.

"Length .14, width .09 of an inch." (Hall.)

Localities.—Spergen Hill, Ellettsville, Stinesville, Romona.

"In the above description the posterior side is referred to as anterior. In a specimen of very much larger size, obtained from later collections (fig. 9), the proportions of parts are somewhat different from those of the type individuals, the posterior extension is less marked and the shell proportionally higher." (Whitfield.)

CYPRICARDINIA INDIANENSIS Hall.

Plate XXIII, figs. 10-14.

Cypricardia indianensis Hall, Trans. Alb. Inst., IV, p. 18, 1858.

"Shell elongate-ovate, narrow and rounded in front; posterior end broader, somewhat compreseed and subulate; base broadly curved; hinge line straight, less than the greatest length of the shell; a line or groove on the inner margin extending from the

beak to the posterior extremity; beaks very small, near the anterior end; umbonal ridge gibbous. Surface marked by distinct, regular, imbricating lamellæ.

"Length from 1/8 to 3/4 of an inch." (Hall.)

Localities: Lanesville, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Paynters Hill, Alton, Ill.

CONOCARDIUM CATASTOMUM Hall.

Plate XXIII, figs. 15-17.

Conocardium catastomum Hall, Trans. Alb. Inst., IV, p. 13, 1858.

"Shell very small, elongate, suncylindrical or subclavate, gibbous in the middle; beaks minute, rising slightly above the hinge line, and anchylosed, anterior end obliquely truncated and obtusely angular on the umbonal slope; the anterior tubular wing minute; posterior end much extended, and constricted near the middle, swelling at the extremity and gaping below. Surface marked with small simple radiating folds which sometimes become obsolete on the anterior end and umbones. Minute undulating concentric striæ cross the radiating folds in well preserved specimens.

"Length, from .125 to .20 of an inch." (Hall.)

Localities: Spergen Hill, Harrodsburg, Bloomington, Stinesville, Elletsville, Romona.

"The most peculiar feature of this species consists in the anchylosis of the valves along the hinge margin. Between the beaks there occurs a small tubercle of solid deposit, firmly uniting them, and often extending along the hinge in the form of a callus. This feature not only occurs in adult individuals, but is also seen on many of small size to so great an extent as to have apparently precluded the possibility of any motion of the valves along the cardinal line. From the examination of a large number of individuals I believe, however, that the feature is caused by a deposit of compact, crystalline carbonate of limes on the inside of the shell after death, which has to some extent forced the beaks asunder and filled the space. On the removal of the chalky substance of the shell this layer is exposed, thus producing the appearance of anchylosis. In cutting specimens across at the beaks this feature is readily seen in section, the layer of carbonate of

lime lining the entire extent of the shell. The idea of a perfect anchylosis of the beaks of a bivalve, it appears to me, is incompatible with the further growth of the shell, and especially so where there is a long hinge line. If in the case of this shell the apparent soldering of the valves at the beaks and along the hinge had occurred, they never could have been separated in front for the admission of water or additional growth, and would as a matter of fact resulted in the death of the animal. The minute size and peculiarly constricted form of the species, sometimes in the younger stages of growth being almost cylindrical, is a very marked and distinguishing character of the species." (Whitfield.)

CONOCARDIUM CARINATUM Hall.

Plate XXIII, figs. 18-19.

Conocardium carinatum Hall, Trans. Alb. Inst., IV, p. 14, 1858.

"Shell sub-trigonal, gibbous in the middle, anterior end cordate; hinge line straight; beaks very small, strongly incurved, rising little above the hinge line; posterior side straight above, sloping upwards from below, gradually tapering to the extremity, faintly constricted at its junction with the body of the shell and gaping below; hiatus elongate-lanceolate, crenulate; umbonal slope strongly carinated; carina reaching from the beak to the base, where it is strongly salient; anterior side obliquely truncate, and abruptly produced into a small conical tubular extension of the hinge line. Surface marked by simple radiating ribs and extremely fine concentric striae, which in passing over the ribs give the surface a granulated appearance. On the anterior slope the ribs are finer and closer than on the sides of the shell, and strongly curved.

"Length, from .20 to .33 of an inch." (Hall.)

Localities: Spergen Hill, Bloomington, Harrodsburg, Stinesville.

"The carina which forms the crest along the anterior umbonal ridge constitutes the distinguishing feature of this form. In other respects it does not appear to differ from *C. cuneatum,* Hall; and, as many specimens are found which are intermediate between the typical specimens of the two, it is probable they are only varieties of one species." (Whitfield.)

CONOCARDIUM CUNEATUM Hall.

Plate XXIII, figs. 24-26.

Conocardium cuneatum Hall, Trans. Alb. Inst., IV, p. 14, 1858.

"Shell sub-trigonal or abruptly calvate; hinge line straight; beaks anchylosed, incurved, very small, rising but little above the hinge line; umbonal slope angular; anterior side truncate, concave just within the angle of the umbonal slope, convex in the middle abruptly produced above, in continuation of the hinge line, in a tubular wing; posterior side vertically compressed, straight along the hinge line, and abruptly declining at the extremity, sloping along the base from the center of the shell to the extremity. Hiatus elongate, extending forward to near the middle of the shell, rounded and expanded at the posterior extremity, and deeply crenulate in the margins of the narrow part. Surface marked by distinct radiating costae, which often alternate in size or bifurcate on the posterior part of the shell; crossed by fine elevated concentric lines of growth, more or less closely arranged. Near the basal margin are some stronger subimbricating ridges parallel to the lines of growth.

"Length, .33 to .50 of an inch." (Hall.)

Localities: Spergen Hill, Bloomington, Harrodsburg, Stinesville.

"The remark 'beaks anchylosed' as applied to this species can not have the same significance as it does in the case of *C. catastomum,* as the most perfectly preserved specimen in the collection has the beaks clean, clear and perfectly free from each other, without any deposit or thickening of any kind between them. The suture of the hinge between the beaks and elsewhere is sometimes very close, and in some cases where the shells have been dead and eroded previously to being imbedded, the line has become entirely obliterated by emaceration. This I presume is what is meant by the statement. The hiatus, or gaping of the valves on the postero-basal line, is sometimes very marked and the thickening of the internal ribs so prominent as to form strong interlocking teeth along the narrow part of it." (Whitfield.)

CONOCARDIUM PERATTENANUM Hall.

Plate XXIII, fig. 20.

Conocardium perattenanum Hall, Trans. Alb. Inst., IV, p. 15, 1858.

"Shell sub-fusiform; hinge line straight, beaks depressed, distinctly anchylosed; from the beaks along the anterior umbonal slope, angle obtuse and scarcely defined; anterior side obtuse, convex in the middle, and gradually sloping upwards from the angles; posterior part of the shell with a broad depression on each side, and again expanding at the extremity with an oblique angular fold, from the hinge line downwards to the hiatus; hiatus broad and expanded behind, narrowed abruptly at the junction of the oblique folds, and thence gradually to the middle of the shell. Surface marked by strong plications, which are much stronger on the anterior part of the shell, and more slender behind. The fold along the anterior umbonal slope bifurcates, sending off on each side a plication, which again bifurcates. Plications crossed by sharply elevated lines, which are more conspicuous on the posterior part, giving it a cancellated appearance.

"Length, .20 of an inch." (Hall.)

Localities: Harrodsburg, Alton, Ill.

"The beaks and upper part of the anterior face of the valves are imperfect, and the apparent anchylosis may be and probably is deceptive. The species is a very distinct and well marked one, differing materially from all the others in the collection in the few strong plicae of the anterior end, and the stronger bifurcating plications of the anterior umbonal ridge." (Whitfield.)

CONOCARDIUM MEEKANUM Hall.

Plate XXIII, figs. 21-23.

Conocardium meekanum Hall, Trans. Alb. Ins., IV, p. 15, 1858.

"Shell sub-angularly ovate or abruptly clavate; hinge line nearly straight, declining at the posterior extremity and sometimes from the beaks; obliquely truncated anteriorly; anterior end convex in the middle, and margined by a narrow sulcus which reaches from the beak to the base just within the obtuse angle of the umbonal slope; posterior end sloping on the base uniformly from the center of the shell to the extremity, contracted behind the body of the

shell; vertically depressed and slightly expanded laterally at the extremity. Surface marked by small, elevated, thread-like radiating lines, which on the posterior part of the shell are crossed by fine concentric striae, giving that part of the shell a cancellated appearance. Anterior depressed end marked by much fainter radiating lines crossed by nearly obsolete traces of fine striae, which converge towards the anterior tubular wing.

"Length, .20 to .33 of an inch." (Hall.)

Localities: Alton, Ill.

"The shells of this species bear considerable general resemblance to those of *C. cuneatum*, but are generally smaller. They vary considerably among themselves, as do those of that species. The one figured is of the broadest and most obtusely cuneate form; others being very much more slender and the umbonal ridge more oblique. One distinguishing feature between the two is in the coarser striae marking the anterior end of the shell of this one, which are not regularly concentric, as in *C. cuneatum*, but successively diverge from the umbonal ridge. The material in which the shells are preserved is well calculated to retain all the surface markings, and consequently the cancellation of the surface is beautifully preserved." (Whitfield.)

CONOCARDIUM EQUILATERALE Hall.

Conocardium equilaterale Hall, Trans. Alb. Inst., IV, p. 16, 1858.

"Shell triangular, sub-equilateral, scarcely gibbous in the middle; hinge line very straight; beaks small, rising a little above the hinge line; anterior end cuneate, sloping gradually from near the center of the shell; umbonal ridge obtuse above, nearly at right angles to the hinge, and subdividing several times before reaching the base; posterior end cuneate, very gradually sloping from the body of the shell; extremity unknown. Surface marked by radiating striae or folds, which are simple or bifurcating, and crossed by fine, regular, elevated, thread-like lines.

"Length and width nearly equal, about .125 of an inch." (Hall.)

"Only a single individual of this species was obtained in all of the collections examined, and this has not been found in the col-

lection since it came into the possession of the Am. Mus. Nat. History. Consequently I have not been able to give illustrations of the species." (Whitfield.)

MICRODON SUBELLIPTICA Hall.

Plate XXIII, figs. 27-29.

Cypricardella subelliptica Hall, Trans. Alb. Ins., IV, p. 17, 1858.

"Shell subelliptical, obliquely truncated at the posterior end; beaks minute at the apex, rising little above the hinge; umbones sub-gibbous, with an undefined elevation extending obliquely towards the posterior basal margin; anterior end narrower than the posterior, rounded at the extremity. Cardinal margin forming an angle with the beak of 25°; base forming a regular elliptical curve. Surface marked by regular, fine, concentric elevated lines which are equal to the spaces between.

"Length, .19 to .32; width, .14 to .24 of an inch." (Hall.)

Localities: Spergen Hill, Harrodsburg, Bloomington, Stinesville.

"The proportionally greater height or shorter form, with rounded antero-basal and posterior margins, will sufficiently distinguish this one from either of the other species associated with it." (Whitfield.)

MICRODON OBLONGA Hall.

Plate XXIII, figs. 30-36.

Cypricardella oblonga Hall, Trans. Alb. Inst., IV., p. 18, 1858.
Cypricardella nucleata Hall, Ibid., p. 17.

"Shell oblong, sub-quadrangular; anterior end narrow, rounded; posterior end broader, flattened, and almost vertically truncate; cardinal margin nearly straight and horizontal behind, declining in front; base nearly parallel to the hinge line; beaks small, somewhat prominent, gibbous below; posterior umbonal slope gibbous or sub-angular, and extending obliquely downwards and backwards to the base of the truncation; lunule small, ovate, deep in the center; escutcheon linear, distinct.

"Length, .09 to .30; width, .06 to .20 of an inch." (Hall.)

Localities.—Spergen Hill, Harrodsburg, Bloomington, Ellettsville, Stinesville, Paynters Hill.

"This species occurs of larger size than any of the others associated with it. When small it is nearly equally high and long, but becomes gradually longer in proportion as it increases in size, so that specimens are often found much more than half as long again as high. In the Geol. Rept. Iowa, 1858, pl. 23, fig. 10, a specimen of this species is figured as *C. nucleata,* probably by mistake. The specimen is one of the original series, and has always been attached to the card marked *C. oblonga.* It corresponds exactly in size to the measurements given of that species in the original description, being .30 of an inch long and .20 of an inch wide; while no measurements are given of *C. nucleata* exceeding one-half that width, and but little more than one-third the length." (Whitfield.)

In discussing *M. nucleata,* Whitfield states that: "This is the smallest form observed, and is of nearly equal height and length in its typical form, but specimens of larger size are proportionately longer, as they increase more in length than in height with increased growth. In consequence of this feature it becomes very difficult if not impossible to distinguish between medium sized individuals of *M. oblonga* and large individuals of this species, and leads one to suspect that they may both belong to one species, especially as the surface markings bear the same proportions to the shell as do those of that species when of the same size."

There can be but little doubt that the small species is the young of the larger one.

MICRODON ELLIPTICUS Whitfield.

Plate XXIII, fig. 37.

Microdon (Cypricardella) sp.? Whitfield, Bull. Amer. Mus. Nat. Hist., I, p. 65, pl. VII, f. 37, 1882.

"Several small examples resembling *M. oblonga* in its proportions of length and breadth, and having an elliptical outline corresponding to that of *M. subelliptica,* have been observed among the later collections from Spergen Hill. It does not appear to be distinct enough from either of the forms to be entitled to rank as a distinct species, but appears to unite the two. A figure of one

of them is given that attention may be directed to it, with the hope of obtaining further information." (Whitfield.)

So far as examined at present our Spergen Hill material does not show any specimens of this variety, though it will doubtless be found. For this reason I am unable to throw any more light on the subject now.

GONIOPHORA? PLICATA Hall.

Plate XXIII, fig. 39.

Cypricardella plicata Hall, Trans. Alb. Inst., IV, p. 18, 1858.

"Shell oblong, sub-quadrate, hinge line slightly arched, the base and hinge line nearly parallel; gibbous in the middle above, and anteriorly, depressed in the middle towards the base; the beaks near the anterior end, small, and scarcely rising above the hinge margin; anterior end short, scarcely extending beyond the beak, rounded; posterior extremity double truncate; a strong fold or angulation extending from the umbo to the posterior basal margin, and a smaller similar fold midway between that and the hinge line, the intervals on the margins between these being truncate. Surface marked with concentric lines of growth.

"Length, .12, width, .12 of an inch." (Hall.)

Localities: Spergen Hill, Bloomington, Stinesville.

"The hinge margin of this species is bounded by a narrow escutcheon, and the ligament has been external. These features, together with the general form of the shell, would throw it into the genus *Goniophora* unless the hinge features may differ, which is scarcely probable. The only other genus to which it has much resemblance is *Pleurophorus*, to which externally, however, it is not so closely related." (Whitfield.)

EDMONDIA? SUBPLANA Hall.

Plate XXIII, fig. 38.

Cypricardia subplana Hall, Trans. Alb. Inst., IV, p. 19, 1858.

"Shell ovate oblong; anterior end very short; posterior end extremely elongate, very gradually narrowing to the extremity which forms a symmetrical elliptical curve; cardinal and basal margins nearly parallel; beaks small; umbonal region depressed convex.

A few obsolete concentric folds on the surface; intermediate portions probably finely striate.

"Length, .69; width, .38 of an inch." (Hall.)

Localities: Lanesville, Spergen Hill, Bloomington, Romona.

"All examples of this species which have been observed have been imperfect. The type specimen is very much water-worn, and although the hinge margin of the shell is very well exposed, it presents no dentition whatever. A second specimen of about the same size, a partial cast, shows a rather large posterior muscular imprint situated near the cardinal margin; but the anterior end is more imperfect. The structure of the hinge so far as revealed, a simple margin with probably an external ligament, will come nearer to the characters of the genus *Edmondia* than to any other known carboniferous form. It certainly is not *Cypricardia*, as that genus is known from recent species." (Whitfield.)

MACRODON? SP.

Plate XXIV, fig. 2.

Shell of rather large size, about twice as long as high, thickness about one-third the height. Greatest height near the posterior extremity. Outline roughly semielliptical, hinge straight, shorter than the greatest length of the shell, posterior extremity rounded, meeting the hinge at an obtuse angle, more sharply rounded to the ventral margin, which is slightly sinuous just below and a little back of the beak, rounding abruptly upward and then backward a little, meeting the hinge at a slightly obtuse angle. Beaks prominent, rising somewhat above the hinge, sloping gradually away to the postero- and antero-ventral margins, with a broad, undefined depression between them extending obliquely downward and backward. Surface apparently smooth except for growth varices. The specimen is not so preserved as to show any but very strong markings. One left valve, loaned by the American Museum.

Length, 33 mm.; height, 16 mm.; thickness, 11 or 12 mm.

Locality: Spergen Hill.

This specimen differs from *M. obsoletus*, in having relatively shorter hinge line and in having growth lines at the extremities, indicating that it had a semielliptical outline. The growth lines

join the hinge at quite an obtuse angle, rather than nearly at right angles.

The generic affinities of this shell are determined only by the outer expression of the valve, as none of the critical characters of the hinge can be seen. It seems to resemble the species of *Macrodon* more than those of any other genus.

GASTEROPODA, CEPHALOPODA AND TRILOBITA OF THE SALEM LIMESTONE.

BY E. R. CUMINGS.

GASTEROPODA.*

[Genus ORTHONYCHIA Hall.]

[ORTHONYCHIA ACUTIROSTRE (Hall) Keyes.]

Plate XXIII, fig. 14; Plate XXV, figs. 13-15.

Platyceras acutirostris (Capulus acutirostris) Hall, Trans. Alb. Inst., IV, p. 31; Geol. Rept. Iowa, 1858, p. 665.

"Shell obliquely conical, more abruptly contracted above, and continued in more slender proportions to the apex, which is incurved, making about a single volution without contact with the body of the shell; aperture sub-circular, margin sinuate, surface sub-plicate, with narrow subangular folds and wider depressed spaces; lines of growth strong, abrupt upon the angles and arching forward on the spaces between."†

There is a very great degree of variability among the specimens of this species, even at the typical localities, and particularly so when a more extended geographical distribution is considered. In the degree of expansion of the shell it is particularly variable, and also in the number and arrangement of the plicae and consequent sinuses of the margin. The apex of the shell may also be short and minute, or long, pointed or enrolled. [Referred to Orthonychia by Keyes, Geol. Mo. V.]

[*Whitfield's valuable paper on the "Spergen Hill" fauna has not reached as wide a constituency of Indiana scientists as could have been wished, hence the present paper is intended to do little more than republish his excellent figures and descriptions with such additional comment and changes in nomenclature as are deemed necessary. The principal additions are in the way of new localities. Several new species are described, one of them, *Subulites Harrodsburgensis*, a very abundant form which has probably escaped detection owing to its close resemblance in its usual state of preservation to certain sea-urchin spines. The writer would have been glad to have revised the species here placed in the genera *Pleurotomaria* and *Murchisonia*; but such a revision would involve a restudy of all Carboniferous forms, an undertaking impossible in the brief time allotted for the work.

All additions and descriptions by the present writer are enclosed in brackets.]

†The portions in quotation marks are from Hall's original paper (quoted by Whitfield). The balance, except portions in brackets, is by Whitfield.

Localities: Spergen Hill, Paynters Hill, Ellettsville, [Harrodsburg], Bloomington, [Stinesville, Romona], and Crawfordsville, Ind.; Warsaw and elsewhere in Illinois, and Tuscumbia, Alabama.

Genus LEPETOPSIS [Whitfield].

Shell patelliform, more or less regularly round or oval, apex sub-central, posterior to the middle and directed backward, the nucleus dextrally coiled; muscular imprint horseshoe-shaped, open (?) in front, consisting of an irregular narrow band which expands more or less at the anterior extremities. Surface of the shell marked by six very indistinct radiating lines, two anterior, two posterior, and two lateral. Type *L. Levettei* White.

It seems as if there were already genera enough among the shells of this group to include any new form that might be discovered, but there is certainly need of some designation other than any existing one, under which forms of this kind that are comparatively numerous in the carboniferous limestones can be placed. They have been usually called *Patella* or *Capulus*, and are often doubtfully referred to *Metoptoma*, but it is quite certain they do not properly belong to either of these genera. *Metoptoma* proper is a very distinct form, and Prof. Phillips, even when proposing that genus, referred forms congeneric with this one to *Patella*. It certainly seems like straining a point to refer these carboniferous shells to a living genus, simply on their general form, when among the living ones such diverse characters are found in the animals as to require several genera, where the shells are undistinguishable from external form alone. I have therefore preferred to risk proposing a new name rather than to refer them to a genus to which I am certain they do not belong. I am slightly in doubt concerning the opening in the muscular impression on the anterior side, as I have not been able to fully see this part. The genus bears some relation to *Anisimyon* M. & H. (see Invert. Pal. U. S. Geol. Surv. Territ., p. 285) in its general appearance, but the nucleus is not reversed and the radiating lines are external, while those of that genus appear strongest on the inside, as ridges.

LEPETOPSIS LEVETTEI (White) Whitf.

Plate XXV, figs. 9–12, and fig. 8.

Lepetopsis levettei (Patella levettei) White, Geol. Ind., 11th Rep., p. 359, pl. 39, figs. 4 and 5.

Shell nearly regularly oval in outline, moderately to depressed convex; apex minute, slightly posterior to the middle of the length; anterior end of the shell more highly convex than behind, the latter portion slightly concave just behind the apex; shell somewhat lamellose in structure and marked by concentric lines of growth; the radiating lines which mark the surface are very faint or obsolete; when seen they divide the shell into six nearly equal parts; length of largest specimen 1.1 inch; width a little less than 1 inch.

In the collection there are two shells, one of which is represented by fig. 8, which appear to be the apical portions of a larger specimen; but possibly they may belong to this species, as both individuals figured show that the apex has been less rapidly expanding than the shell below. It is possible they may represent a distinct species, but they appear so immature that I hesitate to consider them in that light.

Locality: Spergen Hill, Ind.

[Genus STRAPAROLLUS Montfort.]

STRAPAROLLUS SPERGENENSIS (Hall).

Plate XXV, figs. 15–19.

Euomphalus spergenensis Hall, Trans. Alb. Inst., IV, p. 19.
Straparollus spergenensis (Hall) S. A. Miller, Cat. Am. Pal. Foss.

"Shell sub-discoid or planorbiform; spire composed of five or six turns, the inner ones coiled in the same plane, two or three of the outer ones only visible in profile; suture well defined on both sides; volutions rounded below with a distinct obtuse angulation on the upper side, a little distance from the suture; umbilicus nearly twice the breadth of the outer volution; aperture oblique, round-oval, with a slight expansion at the angle on the upper side of the volution. Surface marked by close, fine, equal striae of growth.

"Diameter, .30 to 1 inch; height, .23 to .45 of an inch.

"This shell resembles the *E. lævis* of D'Archiac and DeVerneuil (Trans. Geol. Soc. Lond., vol. VI, 2d series, part 2, p. 363, pl. 33, fig. 7). *E. planorbis* in part of De Koninck. (Carb. Fossils of Belgium, p. 434, pl. 25, fig. 7.)

"Our shell agrees with the description of MM. D'A. and DeV. with the exception of the form of the aperture. The figures given by these authors show the greatest diameter of the aperture to be transverse, while in the species here described the longest diameter is obliquely outwards and downwards from the axis of the shell. Our shells with five turns of the spire are much smaller than *E. lævis* of these authors, and our larger specimens are precisely of the same size as the four inner volutions of their figure.

"It is possible, however, that these deviations which appear constant in our specimens may prove to be only a variety not of specific value. Our specimens of this species, which are numerous, do not lead us to include the *E. planorbis* of D'A. and DeV. as a variety."

The shells of this species are extremely variable, and where large collections of the various stages of growth are examined together, it becomes totally impossible to draw lines of distinction between this and the other three forms associated with it. The var. *Planorbiformis* differs only in the depression of the spire to nearly the plane of the outer volution, the number of volutions even here varying considerably. *E. planispira* has the volutions more slender as well as more numerous, and often the spire becomes so depressed as to present but very little difference between it and the umbilical side. The form originally given as *E. quadrivolvis* is perhaps more distinct and more readily distinguished than any of the others, still intermediate forms are so numerous as to cause great trouble in separating it from the more rapidly expanding specimens of *E. spergenensis*. As the surface markings are alike in all the four varieties, it becomes a question as to whether they may not all belong to one very protean species. However, as they have been described as distinct forms I have given illustrations of each, that others may form their own conclusions.

Localities: The typical form of *E. spergenensis* has been observed at Spergen Hill and Paynters Hill, Bloomington and

Ellettsville, Ind. The other forms have been observed at each locality mentioned except Ellettsville, where it is possible they may occur, as I have seen but few specimens from that locality. [All forms occur at Ellettsville, as also at Stinesville and Harrodsburg, Ind.]

Euomphalus spergenensis var. *planorbiformis* Hall, Trans. Alb. Inst., vol. IV, p. 20. *Straparollus spergenensis* var. *Planorbiformis* (Hall) S. A. Miller, Cat. Am. Pal. Foss. Pl. 25, figs. 20 and 21.

"Shell discoid; spire flat or concave; volutions about four, rounded above and below; aperture nearly circular; umbilicus broad, not deep."

Euomphalus planispira Hall, Trans. Alb. Inst., vol. IV. p. 20. *Straparollus planispira* (Hall) S. A. Miller, Cat. Am. Pal. Foss. Pl. 25, figs. 22 and 23.

"Shell discoid; spire flat or scarcely concave; volutions about five or six, slender, very gradually increasing in size, rounded above and below; suture well defined; aperture circular; umbilicus broad and shallow. Surface marked by fine, closely arranged and slightly undulating striæ.

"Diameter, .36; height, .12 of an inch.

"This shell is distinguished from either of the preceding by its slender volutions which increase much more gradually from the apex. The volutions are round both above and below, though sometimes the lower side descends so abruptly to the umbilicus as to present the appearance of an obtuse or undefined angle on the last volution."

Euomphalus quadrivolvis Hall (*Trans. Alb. Inst., Vol. 4, p. 19.*) *Straparollus quadrivolvis* (Hall), S. A. Miller, Cat. Am. Pal. Foss. Pl. 25, figs. 24 and 25.

"Shell planorbicular, spire depressed, composed of about four turns, the inner one scarcely rising above the last volution; volutions somewhat rapidly increasing from the apex, regularly rounded; aperture round-oval, slightly transverse; umbilicus less than the diameter of the outer volution. Surface marked by fine, closely arranged striae of growth.

"Diameter .12 to .31, elevation .06 to .16 of an inch."

There is so much confusion in regard to the value of the names *Euomphalus* and *straparollus* that I have preferred to leave these species where they were originally placed, rather than to burden the science with additional and useless references by changing them under uncertainty.

[These forms are here referred to the genus *Straparollus* and to the species *S. spergenensis.* There is now no doubt whatever of the correctness of Whitfield's opinion that this is a single protean species. The author has examined thousands of specimens, from a large number of localities, and in any large suite of specimens a separation into the species enumerated by Hall is impossible.]

[Genus STROPHOSTYLUS Hall.]

[STROPHOSTYLUS CARLEYANA (Hall) Keyes.]

Plate XXV, figs. 26 and 27.

Naticopsis Carleyana (*Natica Carleyana* Hall; Trans. Alb. Inst., Vol. 4, p. 31.)

"Shell sub-globose; spire short, consisting of about three volutions, which increase very rapidly, the last one extremely ventricose; suture not distinctly defined; aperture ovate, straight on the columellar side; outer lip sharp; inner lip thickened; columella with a distinct groove near the base of the lip for the reception of the operculum; surface marked by fine elevated striae, corresponding to the lines of growth.

"Height .10 to .30, diameter .08 to .34 of an inch."

This species is very closely related to *N. nana,* M. and W., from the Coal Measures of the Western States, and if mingled with specimens of that species of the same lithological character it would be difficult to separate them. The inside of the aperture on the columellar side is thickened, and the shell imperforate, which characters would remove it from the genus *Natica* to *Naticopsis.* Among some later collections there are specimens which measure fully one-half inch in height, being much larger than those in the original collection.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill., being very rare at the latter locality, while extremely abundant at that first mentioned. [Found also at Harrodsburg, Romona, Stinesville and Ellettsville, Ind.]

Genus MACROCHEILUS Phillips.

Plate XXV, fig. 28.

MACROCHEILUS LITTONANUS Hall.

Natica Littonana Hall, Trans. Alb. Inst., Vol. 4, p. 30.

"Shell short, sub-fusiform; spire depressed-conical; volutions about four, rapidly increasing from the apex, the last volution symmetrically ventricose and prolonged below; suture not strongly marked; aperture narrow-ovate, sharp above, and narrowing near the front; outer lip thin; inner lip thickened; surface striated.

"Height .25, diameter .19; last volution .17 of an inch."

This shell is very erect in form, the columella forming the central axis, unlike any form of *Natica*. The columella of the only specimen in the collection indicates the existence of a very slight twist, showing the features of the genus Macrocheilus to which I have referred it. The surface under a strong hand-glass appears to me to be entirely destitute of markings of any kind, and the suture line between the volutions to have been partially obliterated by a deposit like that of the recent *Ancillaria*.

Locality.—Bloomington, Ind.

[MACROCHEILUS STINESVILLENSIS n. sp.

Plate XXIV, figs. 10-10a.

Shell robust, smooth; spire short but rather abruptly elevated, conical. Four volutions, the first three small and only slightly convex, the last very large and gibbous. Aperture imperfectly preserved but having the general outlines of the genus. Suture shallow. This species differs from *M. littonanus* in the higher, more abruptly elevated spire and less globular shape of the last volution.

Locality.—Stinesville, Indiana, rather rare.

Indiana University collection.]

[MACROCHEILUS sp.

Plate XXIV, figs. 3-3a.

A poorly preserved individual from Spergen Hill is probably referable to this genus.

Indiana University collection.]

Genus HOLOPEA Hall.

HOLOPEA PROUTANA Hall.

Plate XXV, figs. 33 and 34.

Holopea (Callonema?) Proutana Hall; Trans. Alb. Inst., Vol. 4, p. 30.

"Shell ovate-conical; spire somewhat rapidly tapering; volutions about six; moderately convex, last one ventricose, subangular in the direction of the suture line, and obliquely extended below; suture sharply defined; aperture round-ovate, oblique on the upper side; pillar lip slightly reflexed in the umbilical region; umbilicus none; surface marked by fine striae parallel to the lines of growth.

"Length .62 to .50 of an inch."

There is considerable variation in the ventricosity of the volutions in this species, some of them being decidedly flattened in the direction of the spire, while others are quite round and the suture line very distinct. The angulation at the outer base of the last volution is also often obsolete. The shell is minutely perforate, and has a decided umbilical depression at the top of the columella.

Its generic relations with *Holopea symmetrica*, Hall, the first species of the genus described is not very close, but perhaps as near as to any other described genus. It has exactly the characters of *Callonema,* Hall, as shown in *C. bellatula,* except in the surface ornamentation, which is given by the author as a generic feature, although *C. bellatula,* and especially the New York form of it, known as *C. Lichas,* frequently becomes nearly smooth toward the aperture in old shells.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Also Paynters Hill, Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

BULIMORPHA [Whitfield].

Shell fuisiform, spire produced; volutions convex, the last large; columella bent and truncated at the base, where it is separated from the outer lip by a notch as in the recent genus *Achatina;* outer lip very slightly notched near the upper end; surface of the shell smooth. Type *B. bulimiformis,* Hall.

BULIMORPHA BULIMIFORMIS Hall.

Plate XXV, figs. 37-39.

Bulimella bulimiformis Hall, Trans. Alb. Inst., Vol. 4, p. 29; *Polyphemopsis bulimiformis* (Hall), M. and W., Geol. Rept. Ills., Vol. 2, p. 372.

"Shell fusiform, elongate; spire nearly equal to half the length of the entire shell; volutions about six, slightly convex in the middle, increasing somewhat rapidly, the last one equaling in length all the others; aperture elongate-oval, acute at each extremity, slightly sinuate at the upper outer angle; columella slightly curved and truncate at the base; surface smooth or with faint lines of growth.

"Length .25 to .75 of an inch."

This species is the most common one occurring in these beds, and will be found to vary greatly in the proportional length and thickness as well as somewhat in the ventricosity of the volutions.

Localities.—Spergen Hill and Bloomington, Ind. [Also Paynter's Hill, Harrodsburg, Ellettsville, Stinesville, Romona, Ind. Common.]

BULIMORPHA CANALICULATA Hall.

Plate XXV, fig. 41.

Bulimella canaliculata Hall, Trans. Alb. Inst., Vol. 4, p. 29; *Polyphemopsis canaliculata* (Hall), M. and W., Geol. Rept. Ills., Vol. 2, p. 372.

"Shell sub-fusiform; somewhat elongate; spire short, scarcely equaling the length of the last volution; volutions about five, upper ones scarcely convex, rapidly diminishing to the apex, last volution longer than the spire above, slightly ventricose; suture canaliculate, the groove margined by a slight sharp carination at the upper edge of the volution; aperture sub-ovate; surface smooth or marked with fine lines of growth, which are abruptly bent backwards at the carination on the upper edge of the volution which marks the notch in the upper angle of the aperture.

"Length .18 of an inch."

The notch mentioned in the above description is not a notch in the lip like that of *Pleurotomaria, Murchisomia*, etc., but is formed by the channeling of the suture only. This feature at once distinguishes this from any of the other species described.

Locality.—Spergen Hill, Ind. The locality as given under the original description includes Bloomington, Ind., also. Only one characteristic specimen exists in the collection, that being from Spergen Hill, Ind. [Lanesville, Ind.]

BULIMORPHA ELONGATA Hall.

Plate XXV, fig. 40.

Bulimella elongata Hall, Trans. Alb. Inst., Vol. 4, p. 30; *Polyphemopsis elongata* (Hall), M. and W., Geol. Rept. Ill., Vol. 2, p. 372. *Polyphemopsis teretiformis,* Hall; Cat. Am. Pal. Foss., S. A. Miller, p. 245.

"Shell extremely elongate; volutions seven or eight (perhaps nine), somewhat rapidly ascending, moderately convex, the greatest convexity a little above the middle, last one slightly ventricose; suture distinct, an undefined angular elevation below, corresponding to the notch in the lip; surface nearly smooth; direction of the striae scarcely visible.

"Length .50 of an inch."

The undefined angular elevation below the suture mentioned in the description is remarkably obscure in the type specimen, and corresponds only to the "greatest convexity" which exists "a little above the middle" of the volutions. The species is very rare, nearly as much so as *B. canaliculata,* only the type specimen being found in good condition; a few other worn specimens only having been observed. The change of generic name will restore the original specific name of *elongata*, making it *Burlimorpha elongata,* Hall's sp.

Locality.—Spergen Hill, Ind. [Lanesville, Ind.]

Genus CYCLONEMA Hall.

CYCLONEMA LEAVENWORTHANA Hall.

Plate XXV, figs. 29-31.

Pleurotomaria Leavenworthana Hall, Trans. Alb. Inst., Vol. 4, p. 24.

"Shell ranging in form from sub-globose to terete-conical and elongate-ovate; spire conical, varying greatly in its elevation from the young to the old shell; volutions five to seven, neatly rounded and ventricose below; suture well defined; aperture round-oval;

umbilicus none; surface marked by conspicuous, rounded, revolving striae, which are less than the spaces between; striae less conspicuous on the base of the last volution; the first line below the suture uniformly thinner and sharper than the others, and the spaces on each side wider.

"Length from .05 to .50 of an inch."

This shell is remarkably variable in the degree of expansion of the volution, the apical angle being in some cases nearly twice as great as in others, while the increase in the volution is equally variable. These changes give one the impression, when only a few individuals are examined, that there are two distinct species represented, but so many connecting forms can easily be obtained that one soon abandons this view. The species presents no evidence of being a true *Pleurotomaria,* as there is no indication of a notch between any of the revolving striae. The characters correspond much more nearly to those of *Cyclonema,* Hall, although it lacks the flattening of the columella that is seen in *C. bilix.*

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Also Harrodsburg, Ellettsville, Stinesville, Paynters Hill and Romona, Ind. Abundant.]

CYCLONEMA SUBANGULATUM Hall.

Plate XXV, fig. 32.

Pleurotomaria subangulata Hall, Trans. Alb. Inst., Vol. 4, p. 25.

"Shell ovate-conical; volutions about five or six, angular above, the last one ventricose below; upper side of volution nearly rectangular to the direction of the spire; aperture ovate, the inner side straight or concave; umbilicus none; suture distinct; surface ornamented by unequal, revolving lines, those on the lower part of the last volution finer and more closely arranged, three of those on the periphery stronger and more distant, the upper one of these three stronger than the other two, forming the summit of the angle; midway between the angle and the suture is one strong angular stria, and on the outer side, and sometimes on the inner side of this a finer one.."

"Length .35 of an inch."

This shell is closely allied to *C. Leavenworthana,* and will most likely prove to be only a variety of that one. The carinated upper

angle of the last volution is caused by the dropping out of the revolving line below it, and to some extent also that above, causing this individual line to stand out more prominently. In the form of the lower part of the volution and in that of the aperture they agree perfectly.

Locality.—Spergen Hill, Ind. [Harrodsburg, Bloomington and Stinesville, Ind.]

Genus LOXONEMA Phillips.

LOXONEMA YANDELLANA Hall.

Plate XXV, figs. 35 and 36.

Trans. Alb. Inst., Vol. 4, p. 28.

"Shell terete-subulate; spire elongate, very gradully tapering to the apex, which is apparently obtuse; volutions about eight or nine; very little convex, the last one scarcely expanded; suture distinct; surface marked by fine thread-like striae crossing the volutions with a slight undulation above the middle; aperture ovate.

"Length .20 to .50 of an inch."

This species has proved to be exceedingly rare, and so far as seen is usually quite small. The fragment figured represents the largest growth yet noticed, while the surface markings are much stronger proportionally than on any other specimen examined.

Locality.—Spergen Hill, Ind. [Also Harrodsburg, Romona and Big Creek (Stinesvile), Ind.]

Loxonema vincta, see Murchisonia vincta.

The shell described in the original Spergen Hill paper as *Pleurotomaria concava* presents features entirely incompatible with those of any known genus so far as I can ascertain. It is trochiform, being broadly conical above and flattened or concave below, with a wide umbilicus extending to the nucleus of the spire, as in Solarium. The aperture is very oblique, and the periphery of the volutions is extended in form of a thin flange, under which the succeeding volution is formed. No apertural slit exists, nor are the striae of growth interrupted at the periphery, except when the expansion is broken off. The surface ornamentation consists of simple lines of growth above, while below the flattened surface is marked by revolving lines. For this and similar species I propose the generic name *Eotrochus*.

EOTROCHUS [Whitfield].

Shell conical above, flat or concave beneath and broadly and deeply umbilicated. Aperture very oblique, and the outer angle of volutions strongly carinated or expanded. Surface ornamentation unlike on the upper and lower surfaces. Type E. CONCAVA *Pleurotomaria concava,* Hall.

The genus differs from the umbilicated forms of the Trochidae in not having the inner or umbilical surface of the volution distinct from the basal parts (i. e., not forming a columella), but the lower or basal surface of the volution slopes gradually and smoothly into, and forms the sides of the umbilicus, giving an obliquely elliptical section to the volution. From the forms usually placed under *Onustus,* Humph., it differs but little except in the character of growth and surface of the lower side of the volutions. So far as known, it forms no peripheral digitations or ornamentation as in that genus. In the Pal. Rept. of Ohio, Vol. 1, p. 221, Mr. F. B. Meek proposes the name *Pseudophorus* for a group of shells which he referred with doubt to *Xenophora,* Fischer, but which he does not characterize. The shell for which he proposed it, however, differs widely in character from the one under consideration; it being imperforate, although having a broad umbilical depression, and the lower surface of the shell is a direct continuation of the upper surface like the volution of *Platyostoma* or *Natica,* only being angulated on the periphery, while this one possesses a distinct system of growth and surface markings. This with the open umbilicus is sufficient to distinguish it as a separate generic group, the Ohio shell being only a flattened *Platyostoma.*

EOTROCHUS CONCAVUS (Hall).

Plate XXVI, figs. 21-23.

Pleurotomaria concava Hall, Trans. Alb. Inst., Vol. 4, p. 24; *P. tenuimarginata,* Hall; Cat. Am. Pal. Foss., S. A. Miller, p. 245.

"Shell trochiform; spire depressed-conical; volutions about five, flattened or slightly concave above; base of shell concave; periphery alate, alation curving downwards at the margin; aperture transversely ovate (the wider part at the pillar); umbilicus medium size, round; suture linear, rather indistinct; surface smooth

or marked by obsolescent striae, which turn abruptly backwards from the suture to the periphery; similar striae are sometimes visible on the base of the shell, bending abruptly backward on the alation.

"Diameter .25 to .75 of an inch, height from .20 to near .50 of an inch."

The original specimens of this species were so very poor that they seem to have led to some misconceptions of characters. On clearing away the rock from the base of some of the larger specimens the surface of this part is seen to be marked by about thirteen flattened revolving lines, and with the strongest hand glass no oblique lines resembling those on the upper surface can be seen, although the apparent receding of the lower lip of the aperture would give this direction. The "pillar" spoken of in describing the form of aperture should not be interpreted as indicating a solid columella, but only the wall of the open umbilicus. The largest specimen in the collection has a diameter of considerably more than one inch.

Localities.—Spergen Hill, Ind., and Alton, Ill. No individual from Bloomington is present in the collection. [Paynter's Hill and Stinesville, Ind.]

Genus PLEUROTOMARIA,* D. France.

PLEUROTOMARIA SUBGLOBOSA Hall.

Plate XXVI, fig. 10.

Cat. Am. Pal. Foss., S. A. Miller, p. 245. *P. rotundata* Hall, Trans. Alb. Inst., Vol. 4, p. 23.

"Shell sub-globose; volutions above five or six, convex, the last one very rotund or ventricose; suture distinctly marked, and the volution depressed just below it, and rising in an obtuse, undefined angle, below which is a distinct depressed revolving line, and below this again a similar sub-angular elevation, which forms the upper limit of the broad periphery of the outer volution, thus making the upper side of the volution obscurely biangular with one depression between the angles and the other towards the suture.

*None of the species described herein under the genus, *Pleurotomaria*, belong to that genus in the restricted sense. The time at the writer's disposal has not made it possible to give the species the necessary revision for final generic reference.—E. R. C.

These angles and the depression between are distinctly visible in the cast. Aperture broadly ovate; umbilicus small; surface marked by fine, closely arranged revolving striae.

"Diameter .09 to .45, height .04 to .38 of an inch."

On the larger individuals of this species the volutions are entirely round above and on the sides, completely destroying the subangulations spoken of in the description, the depressed band being most distinct in the small and medium-sized individuals. But the term "biangular" is, perhaps, too marked to apply to so round and globular a shell. The umbilicus is very distinct when clear of adhering rock, and its margin abrupt. On very well preserved specimens the under side is seen to be marked by very fine revolving lines, but those on the upper side of the volutions only are visible on most examples.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

PLEUROTOMARIA SWALLOVANA Hall.

Plate XXVI, figs. 1 and 2.

Trans. Alb. Inst., Vol. 4, p. 24.

"Shell depressed, somewhat globose, spire little elevated; volutions about five, regularly rounded, the last one sub-ventricose, and sometimes a little more expanded at the periphery; suture well defined; aperture sub-circular, a little oblique on the pillar; umbilicus large, circular; a flattened band upon the periphery of the shell margined on each side by a distinct elevated line; volutions crossed by fine, even, thread-like striae, which are smaller than the spaces between them, more conspicuous on the upper side of the volutions and often obsolete on the lower side.

"Diameter .12 to .25, height .07 to .20 of an inch."

The general resemblance of this species is somewhat similar to that of *P. subglobosa*, but it is much more depressed, although very variable in this respect. The transverse striae on the upper surface of the volution, and the situation of the band which is on the periphery in this case, will serve to distinguish this species.

Localities.—Spergen Hill and Bloomington, Ind. [Also Paynters Hill, Ellettsville and Stinesville, Ind.]

PLEUROTOMARIA TRILINEATA Hall.

Plate XXVI, fig. 20.

Trans. Alb. Inst., Voi. 4, p. 25.

"Shell ovate-conical; spire more or less elevated, acute at the apex; volutions about six, convex, last volution ventricose; suture distinctly defined; aperture sub-circular; columella perforate by a small umbilicus; surface marked upon the periphery by a comparatively broad spiral band, which is margined on each side by a linear groove; two other similar grooves between the band and the umbilicus, dividing the base of the shell into three spaces, each one equaling in width the spiral band; entire surface, except the spiral band, ornamented by revolving, thread-like striae, which are crossed by fine lines of growth, the latter becoming stronger and curving slightly backward upon the spiral band; an almost imperceptible angulation just below the umbilicus.

"Length .125 to .50 of an inch."

The measurement ".125" as given in the original paper is probably a misprint and should be .25. The largest specimen which I have observed is about .75 of an inch high.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

PLEUROTOMARIA NODULOSTRIATA Hall.

Plate XXVI, fig. 5.

Trans. Alb. Inst., Vol. 4, p. 21.

"Shell turbinate; spire depressed-conical, obtuse at the apex; volutions about four, rounded, somewhat depressed above, the last one ventricose below; suture distinct, rather sharply defined; aperture sub-circular, slightly flattened on the inner side; umbilicus rudimentary; surface marked by strong, revolving elevated striae, which are about equal to the spaces between them, excepting on the periphery of the outer volution, where two or three are more distant, leaving a double spiral band; revolving striae crossed by oblique striae (parallel to the lines of growth), which are very conspicuous on the upper side of the volution, but become obsolete below the band. The revolving lines at the junction of the oblique striae become nodulose on the upper half of the volution, and particularly near the suture.

"Diameter .12 to .18, height .10 to .18 of an inch."

In most of the specimens, especially the larger ones, the upper side of the volution is obliquely flattened in the direction of the apical angle, and the periphery vertically flattened. They vary greatly in the rate of increase, the apical angle varying from less than 60 to about 90 degrees in different specimens. There are apparently two strong varieties included among those referred to the species, one having coarse revolving lines on the lower side, the other marked by very fine lines, the latter having a very depressed spire and flattened periphery, though I think there are intermediate forms enough to unite them.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Harrodsburg, Ellettsville and Stinesville, Ind.]

PLEUROTOMARIA WORTHENI Hall.

Plate XXVI, fig. 4.

Trans. Alb. Inst., Vol. 4, p. 23; Geol. Rept. Iowa, 1858, p. 530, pl. 23, fig. 13.

"Shell depressed sub-globose; spire but little elevated, oblique from the great expansion of the last volution; volutions about three, somewhat flattened above, rapidly expanding, so that the last volution makes nearly the whole bulk of the shell; obtusely angulate on the periphery; upper margin of the volutions marked by a row of strong nodes, which extend about one-third across; surface marked above by striae parallel to the lines of growth, which on the last volution disappear in passing over the angulate periphery; base of last volution marked by strong revolving lines on the space between the outer margin and the umbilical area; base deeply excavated about the umbilical region, but the umbilicus is unknown. Aperture sub-quadrate, upper edge of the outer lip projecting far over the lower.

"Diameter .60, height .48 of an inch."

This shell is not a very characteristic form of *Pleurotomaria*. In fact, it approaches much nearer to the genus CRYPTAENIA, Deslonch, Mem. Soc. Lin., Vol. VIII, p. 147, than to the true *Pleurotomaria*, as the slit in the periphery has been very obscure and concealed by the succeeding volutions. The form is also depressed and the aperture very oblique, receding very much on the lower side. I have not been able to ascertain the form of the umbilicus in *Cryptaenia*, but in this species the depression is very broad

and patulose, although the real perforation itself is very small indeed. The row of nodes mentioned in the description as characterizing the upper side of the volution, have the form of undulations of this part of the shell, are somewhat oblique and only pertain to the last one or one and a half volutions. The surface of the shell when not worn is covered by revolving lines both above and below, except within the umbilical depression, the very margin of this only being marked.

Localities.—Spergen Hill and Bloomington, Ind.

PLEUROTOMARIA HUMILIS Hall.

Plate XXVI, fig. 3.

Trans. Alb. Inst., Vol. 4, p. 21.

"Shell depressed, trochiform, oblique, spire little elevated, consisting of three or four volutions, which increase rapidly in size from the apex; volutions depressed-convex above, and declining to the periphery; base of the last volution less convex than on the upper side, sub-obtusely angular on the periphery, which is marked by a narrow groove, little wider than the usual spaces between the revolving striae; surface marked by revolving and transverse striae, which are stronger and more distant on the upper side of the volution, giving it a beautiful cancellated appearance, while they are closer and finer on the lower side of the shell; mouth transversely oval; umbilicus small.

"Diameter .10 to .19, height .07 to .14 of an inch."

The specimens upon which this species was founded, and of which the above is the description, are only the young shells of *Pleurotomaria Wortheni* Hall, and their locality the same as that species.

[Additional material from other localities makes it certain that *P. humilis* and *P. wortheni* are one species.]

PLEUROTOMARIA MEEKANA Hall.

Plate XXVI, figs. 8 and 9.

Trans. Alb. Inst., Vol. 4, p. 22.

"Shell depressed-conical; spire short, rapidly diminishing and obtuse at the apex; volutions about five, appressed above and subangular below, with the periphery vertical; suture distinct; last

volution large, not ventricose, biangular on the periphery, with a defined groove in the center which is distinctly margined above and below by an elevated line; surface on the upper side of the volutions marked by revolving and transverse striae of equal strength, which are regularly cancellated (and when not worn there is a slight nodosity at the crossing). The revolving lines on the base of the last volution are closer and finer than those above, and equally but less distinctly crossed by the transverse lines, which make a deep sinuosity on the periphery of the shell. Aperture sub-quadrate, with a deep notch in the outer margin at the termination of the revolving band; umbilicus of medium size.

"Diameter .18, height .13 of an inch."

The species is represented in the collection by only a single imperfect specimen, on which the characters are rather obscure. It has more the form of a *Trochonema* than of a *Pleurotomaria* in the general form of the shell and spire. There is but very indistinct evidence of the "deep notch" in the outer margin of the shell, and I can not detect any revolving lines on the lower side of the last volution as stated.

Locality.—In the original paper the locality is given as Spergen Hill, but the card is marked Alton, and the specimen shows the lithological characters of the rock from that locality. Therefore I think it probable the locality has been wrongly stated by mistake.

[The Indiana University collections contain a considerable number of specimens of this species from Stinesville, Ellettsville and Harrodsburg, Ind.]

PLEUROTOMARIA PIASAENSIS Hall.

Plate XXVI, figs. 6 and 7.

Trans. Alb. Inst., Vol. 4, p. 22.

"Shell depressed, sub-globose; spire short and little elevated, consisting of about four volutions; volutions rapidly increasing in size, depressed-convex above, somewhat rounded below, and becoming sub-angular near the aperture; the periphery abruptly rounded and marked by a spiral groove or band; surface marked by about four strong spiral or revolving striae on the upper side of the volution, between the periphery and suture, and four or five similar

striae on the lower side; transverse striae scarcely distinct except in the spaces between the revolving striae; umbilical depression rather broad, and margined by a strong angular elevation towards the aperture of the shell; aperture sub-quadrangular, the pillar side shorter; the outer side, from the periphery to the angle bordering the umbilical region, nearly straight, and equal to the space from the periphery to the suture.

"Diameter .17, height .10 to .11 of an inch."

The shells of this species are very variable in the form of the volutions, some being round on the periphery and others quite angular, that figured being of the latter group. Of course this sharpness on the edge gives a more obliquely flattened form to the upper and lower surface, destroying to a considerable extent the "sub-globose" form as mentioned in the original description. The number of bands and the strength of the transverse striae also vary. On the angular specimens there is often a carinated band forming the margin, when it becomes difficult to distinguish the position of the slit which should characterize the genus to which it is referred.

Locality.—Piasa Creek, above Alton, Ill., the locality of the Alton bed. [Paynters Hill, Ellettsville and Stinesville, Ind.]

PLEUROTOMARIA CONULA Hall.

Plate XXVI, fig. 17.

Pleurotamria (Murchisonia?) Conula, Hall; Trans. Alb. Inst., Vol. 4, p. 26.

"Shell conical, spire gradually and uniformly diminishing from the base; volutions six to eight, angular in the middle and flattened above and below; sutures defined; surface marked by distinct, elevated, nearly vertical striae, both above and below the spiral band; spiral band occupying the periphery of the volution, and composed of three revolving minute carinations with narrow depressions between (sometimes only two elevated bands are visible); aperture sub-quadrate; columella extended below, perforate.

"Length from .08 to .18 of an inch."

The generic relations of this shell are rather obscure, as it seems to be intermediate between *Murchisonia* and *Pleurotomaria.* If it were not perforated it would form a very good *Murchisonia.*

but the type of that genus has a solid axis, and all true species of the genus in the Devonian have, while this species is very distinctly umbilicated. The slit in the aperture is very narrow, and in the specimen figured is seen to be open for nearly an entire volution, becoming gradually narrower as it recedes from the aperture, and in closing finally forms the third carination of the band mentioned in the description.

Locality.—Spergen Hill, Ind. [Also Paynters Hill, Romona, Stinesville, Ellettsville and Harrodsburg, Ind.]

[BEMBEXIA ELEGANTULA (Hall) Ulrich.*]

Plate XXVI, fig. 19.

Pleurotomaria elegantula, Hall sp. [Whitfield]; *Murchisonia elegantula,* Hall; Trans. Alb. Inst., Vol. 4, p. 27; *Pleurotomaria Shumardi,* M. and W., Geol. Surv. Ill., Vol. 2, p. 260, pl. 18, fig. 6.

As the original description of this species was taken from a very imperfect and immature specimen, it is very incomplete, and I have thought best to substitute that given by Messrs. Meek and Worthen, *loc cit.,* which is much better. The shell is very good *Pleurotomaria,* and does not in its complete form possess the features of the genus *Murchisonia.*

"Shell trochiform, of medium size, very thin; spire moderately elevated, conical, somewhat attenuate at the apex. Volutions about seven, increasing rather rapidly in size, obliquely flattened above; those of the spire somewhat angular near the lower side; last one very prominent and angular around the middle, moderately convex below, the immediate edge of the angle being truncated by the narrow spiral band. Band flat or slightly concave, and margined above and below by a small, smooth, slightly elevated line; passing around a little above the suture on the whorls of the spire. Suture well defined; umbilicus small; aperture rhombic-subquadrate, wider than high. Surface ornamented by numerous transverse lines, which are very regular and closely ar-

[*In his remarks on the family *Pleurotomariidae* Mr. E. O. Ulrich (Geol. Minn., Vol. III, Pt. II, 1892-1896, pp. 946-960) has subdivided the genus into a number of subordinate groups or genera, and refers to certain of these genera, a number of species occurring in the present fauna. Those interested in the present status of the *Pleurotomariidae* should consult the works of Koken, Burkhardt, and Ulrich.]

ranged on the upper whorls, but become stronger, more distant and less regular on the last turn. In crossing the upper, flattened, sloping sides of the whorls, these lines arch a little forward and pass very obliquely backwards from the suture to the band; on the under side of the body whorl they are smaller, or nearly obsolete, and crossed by obscure traces of fine revolving striae. Length 0.70 inch, breadth 0.73 inch; apical angle rather distinctly concave; divergence 0.70."

Localities.—Bloomington, Ind., and Warsaw, Ill. [Stinesville, Ind.]

Genus MURCHISONIA. D'Arch. and Vern.

MURCHISONIA INSCULPTA Hall.

Plate XXVI, fig. 18.

Trans. Alb. Inst., Vol. 4, p. 26.

"Shell subulate-conical; spire somewhat rapidly ascending, acute; volutions six or seven, convex and rounded in the middle, appressed and sloping gradually above, and abruptly below, to the suture; upper side of volutions marked by vertical elongate nodes, which are pointed above and gradually disappear in the surface below, or subdivide into distinct elevated striae; spiral band rather broad, margined by two distinct elevated lines, with the intermediate space convex or concave; last volution ventricose, extended below and marked by an elevated line which is a continuation of the suture line; aperture somewhat rounded and extended in front; columella extended below and imperforate.

"Length from .05 to .25 of an inch."

The species approaches more nearly to *Pleurotomaria conula* than to any other associated species, but can be readily distinguished by the more highly conical form, coarser markings, more extended aperture, more ventricose last volution, which is longer on the lower side, and by not being umbilicated. The slit in the last volution extends from the margin of the aperture backwards for about one-fourth to one-third of a volution.

Localities.—Spergen Hill and Bloomington, Ind. [Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

MURCHISONIA TEREBRIFORMIS Hall.

Plate XXVI, figs. 15 and 16.

Trans. Alb. Inst., Vol. 4, p. 28.

"Shell extremely elongate, sublate-acute; volutions eight or nine, very convex, marked by a broad spiral band in the center, last volution ventricose; suture deeply marked; surface ornamented on the upper side of the volutions by fine striae, which extend obliquely backwards to the spiral band, below the band by one or two spiral elevated striae, and on the last volution by four or five similar striae; aperture unknown; umbilicus none.

"Length .33 of an inch."

This shell resembles in its general features *Pleurotomaria trilineata*, Hall, herein described, but is more elevated than the most slender forms of that species, and has a less ventricose volution as well as a greater number of whorls. The surface ornamentation is quite distinct, as there are none of the fine revolving lines above the band on this one, the surface being marked by transverse striae only, and the revolving lines below are raised, flattened, narrow bands instead of impressed lines, as on that one. The shell is also imperforate.

Locality.—Bloomington, Ind. [Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

[SOLENOSPIRA VERMICULA (Hall) Ulrich.]

Plate XXVI, fig. 11.

Murchisonia vermicula, Hall [Whitfield]; Trans. Alb. Inst., Vol. 4, p. 27.

"Shell cylindrical, abruptly tapering at the apex; volutions from six to ten, moderately convex in the middle and scarcely diminishing for the first four or five turns above the base, but becoming more abruptly contracted above; surface of each volution marked by two very prominent revolving striae, having a space between them on the periphery, and a single finer line below and one above near the suture; the last volution not ventricose, and marked by a fifth revolving striation, which is a continuation of the suture line; aperture broadly oval, rounded below; columella imperforate. Shell minute.

"Length .14 of an inch."

This is the smallest gasteropod found in the Spergen Hill beds, and is extremely abundant in certain layers. The shell is nearly cylindrical for more than half its length in the larger specimens, the increase being mostly in the upper four or five volutions. The spiral bands are often nearly obsolete, or the upper and lower are indistinct, and the central ones very strongly marked. It is readily distinguished from the apical portion of *M. turritella* by its clindrical form, that one being regularly tapering. [Ulrich, *loc. cit.*, refers this form to the genus *Solenospira.*]

Localities.—Spergen Hill and Bloomington, Ind. [Paynters Hill, Harrodsburg, Bloomington, Ellettsville, Stinesville and Romona, Ind., abundant.]

[SOLENOSPIRA TURRITELLA (Hall) Ulrich.]

Plate XXVI, fig. 12.

Murchisonia turritella, Hall [Whitfield]; Trans, Alb. Inst., Vol. 4, p. 27.

"Shell subulate, elongate, gradually tapering to the apex; suture distinct; volutions about nine; equally rounded, the last one slightly ventricose; surface marked by closely arranged, rounded, revolving striae, which are stronger on the middle of the volution; five revolving striae on each volution of the spire, and about seven on the last volution: aperture sub-ovate; columella slightly extended and curved around the aperture, imperforate.

"Length .18 to .50 of an inch."

The shells of this species are very variable in their rate of increase and in the comparative height of the volutions, as also in the strength of the revolving lines. These latter are often quite sharp or angular, or others are rounded as stated in the description above. The band marking the slit in the lip is situated above the middle of the volution, and is not well marked until the shell attains considerable size, when it becomes distinct. This feature gives a central or sub-central line, so that there are five lines exposed on each volution. There is but one associated species with which it will be readily confounded, namely, *M. attenuata,* under which species comparisons will be found. [Ulrich, *loc. cit.*, refers this species to the genus *Solenospira.*]

Locality.—Spergen Hill, Ind. [Paynters Hill, Harrodsburg, Bloomington, Big Creek (Stinesville) and Romona, Ind.]

[SOLENOSPIRA ATTENUATA (Hall) Ulrich.]

Plate XXVI, fig. 13.

Murchisonia attenuata, Hall [Whitfield]; Trans. Alb. Inst., Vol. 4, p. 27.

"Shell subulate, elongate; spire very gradually tapering; volutions nine or more, flattened, scarcely convex in the middle, and marked by a spiral band which is margined on either side by a strong elevated line; suture bounded on each side by a sharp elevated line which is smaller than those bordering the spiral band; aperture transverse; umbilicus none."

There will always be considerable difficulty in distinguishing between this one and *M. turritella,* more especially so as no perfect specimens of this have been observed, so that the entire characters are unknown. It is probably a distinct species, but the only distinction that remains constant, even among the small number of individuals observed (some five), consists of the number of revolving lines, which on this one is four, and on that five. As a pretty general thing they are sharper on this form, and those near the suture line less distinctly so than those bordering the band. This feature destroys that roundness of the volutions so characteristic of *M. turritella.* The band is also situated near the middle of the volution, and the shell is perhaps a little more slender. [Ulrich, *loc. cit.,* refers this species to the genus *Solenospira.*]

Locality.—Spergen Hill, Ind. [Paynter's Hill, Harrodsburg, Bloomington, Ellettsville, Stinesville and Romona, Ind.

The Indiana University collection contains a considerable number of specimens of this species. It is probably distinct from *S. turritella.*]

MURCHISONIA VINCTA (Hall).

Plate XXVI, fig. 14.

Loxonema vincta, Hall; Trans. Alb. Inst., Vol. 4, p. 28.

"Shell extremely elongate, very gradually tapering from the base; volutions convex below, appressed above, banded just below the suture and marked by transverse arching striae; aperture ovate, wider below; umbilicus none.

"Length 1 inch."

The description given of this species is very incomplete, and the specimens are usually too imperfect to afford means for better.

The volutions have been as much as ten or twelve in number, are very little convex, the upper half being depressed from the presence of a broad concave band just above the center, which gives them an obliquely flattened character, and throws the greatest convexity below the middle, often causing a slight angularity and leaving a narrow, flattened band below the suture line above the band. This form is so common a feature of the genus *Loxonema* that it is very natural to make the wrong generic reference, especially as the surface markings are extremely fine and often obsolete. In the type specimen, however, they can be seen with a good glass and show a dcided recurving in crossing the depressed band, showing decidedly its generic affinities with *Murchisonia*. It is the largest shell of the form found in these beds, and is readily distinguished from any of the non-lirated species by its more slender form, and from those by its greater size and smooth volutions.

Locality.—All the specimens yet observed have been from Spergen Hill, Ind. [Ellettsville, Stinesville and Romona, Ind.]

HETEROPODA.*

Genus BELLEROPHON, Montf.

BELLEROPHON SUBLÆVIS Hall.

Plate XXV, figs. 6 and 7.

Trans. Alb. Inst., Vol. 4, p. 32; Geol. Iowa, 1858, p. 666, pl. 23, fig. 15.

"Shell sub-globose, inflated on the last volution; aperture transverse, arcuate, expanded, the lip thickened and much extended at the junction with the volution; umbilicus none; dorsum carinated by a narrow, slightly elevated carina, surface ornamented by fine, regular striae, which bend abruptly and deeply backwards on the carina, denoting the depth of the emargination of the lip; striae sometimes irregular from interrupted growth.

"Length from .062 to .875 of an inch."

This shell belongs to the non-umbilicated section of the genus, and in the adult shell the lip is much thickened over the umbilical area, so as to form a strong callus, while in the younger stages it is

* The genus BELLEROPHON is not now placed in the HETEROPODA, but occupies a position in the RIPHIDOGLOSSA near the *Pleurotomaridæ*.

but slightly thickened, or in the very young is thin and scarcely enrolled. The volutions are strongly embracing, the last one so much so as to give a deeply reniform aperture. The dorsal keel is but slightly marked and very narrow, and in very many of the larger individuals becomes entirely obsolete, either from an external deposit or from a kind of erosion which has taken place before the shells were finally imbedded, and which has also obliterated the surface markings. Besides the broad emargination of the lip indicated by the transverse lines of growth, they sometimes show a deep slit of the width of the dorsal band extending an eighth of an inch or more from the margin of the lip. There is no described species from the lower Carboniferous formations that approaches very near this one. *B. Stevensianus*, McChes., Pal. Foss., pl. 2, fig. 18, from the Coal Measures of Illinois and the West, is as near as any, but is compressed laterally, more strongly marked and more distinctly carinate. Specimens measuring an inch and one-eighth have been more recently obtained at Spergen Hill and at Ellettsville, Ind.

Localities.—Spergen Hill, Bloomington, Paynter's Hill and Ellettsville, Ind., and Alton, Ill. [Also Harrodsburg and Stinesville, Ind.]

[BELLEROPHON SP?

A specimen from Spergen Hill only generically identified.]

[BELLEROPHON GIBSONI White.

Plate XXIV, figs. 5-5b.

Indiana, Dept. Geol. and Nat. Resources, Vol. II 1881, p. 360, pl. 41, figs. 4, 5 and 6.

"Shell very large for a species of this genus; whorls gradually increasing in size, broadly rounded on the outer side, especially on the outer portion of the last one; aperture large, expanding by reflexion of the lip at the sides, but apparently not so expanding in front.

"The larger examples, when perfect, had a length of at least 65 millimeters and a breadth of aperture of 50 mm."

* * * * * * * * *

"Position and Locality.—St. Louis group of the Subcarboniferous limestone series, Greencastle, Putnam County, Indiana."

(White, *loc. cit.*) Ellettsville, Bedford and Bloomington, Indiana, in the Salem limestone.]

[BUCANOPSIS TEXTILIS (Hall) Ulrich.]

Plate XXV, figs 4 and 5.

Bellerophon textilis, Hall [Whitfield]; *Bellerophon textilis* Hall; Cat. Pal. Foss. S. A. Miller, 1877; *B. cancellatus,* Hall, Trans. Alb. Inst., Vol. 4, p. 31.

"Shell sub-globose; aperture transversely oval, arcuate, with the lip reflexed at the sides; umbilicus small in young shells and scarcely visible in the older specimens from the thickening of the lip; surface marked by fine longitudinal elevated striae, of which about thirty may be counted on each side of the carina, increasing by implantation with the age of the shell; carina rather narrow and little elevated, very indistinctly marked by the longitudinal striae. Transverse striae in the direction of the lines of growth, irregular, subimbricate, more distant than the longitudinal striae, bending backwards on the carina. At the crossing of the two sets of striae the surface is slightly nodulose in well preserved specimens.

"Length .125 to .75 of an inch or more."

This is the only cancellated form described from the Carboniferous rocks of the Western States, and is a form more characteristic of the Devonian and Waverly formations than of this horizon. The shells which I have seen all have the appearance of immaturity, and there is an uncertainty as to whether the lip may or may not have been reflected in the adult stages, like those of the same type in the lower formations mentioned. If it were thin and unreflected as in the specimens known, this alone would be a distinguishing mark. But the even cancellation of the surface otherwise distinguishes it from all except *B. Leda,* Hall, from the Hamilton shales of New York, which always has a broader band, and is rather more decidedly umbilicate. [Ulrich, *loc cit.,* refers this species to the genus *Bucanopsis.*]

Localities.—Spergen Hill and Bloomington, Ind. [Also Paynter's Hill, Harrodsburg and Stinesville, Ind.]

[Genus SUBULITES Conrad.

SUBULITES HARRODSBURGENSIS n. sp.

Plate XXIV, figs. 7-7b.

Shell very elongate, cigar-shaped, smooth; spire long, tapering very gradually. Volutions flat, seven or eight in number, rather oblique; last volutions scarcely larger than the one preceding. Suture scarcely visible, even in well preserved examples. In poorly preserved specimens and in all specimens except under a magnifier, the surface appears perfectly smooth, causing these shells tc bear an astonishing resemblance to somewhat worn sea-urchin spines. Aperture notch-shaped, short and abruptly truncated at the bottom. Inner lip thickened. Length of average specimens from 5 to 6.5 mm., diameter 1.0 mm. to 1.5 mm.

Harrodsburg, Ind., abundant; Bloomington, Ind., rare.

Indiana University collection.]

[Genus SOLENISCUS M. & W.

SOLENISCUS GLABER n. sp.

Plate XXIV, figs. 9-9a.

Shell conical smooth, spire sharp, conical and well elevated; volutions five, smooth, flat or slightly convex, last volution more convex and very large. Suture shallow, not strongly marked. Aperture elongate-oval pointed both above and below. Outer lip thin and sharply defined. Columella spirally twisted so as to give the effect of a ridge on the inner margin of the aperture. The base of the columella is channelled. Length of largest specimen 9 mm., diameter of last volution 4.5 mm. Only a few specimens of this species have been seen.

Locality.—Spergen Hill, Ind., very rare.

Indiana University collection.]

[PLATYCERAS CIRCULARIS Rowley sp.

Plate XXIV, figs. 11-11a.

Indiana Paleontology, VIII, Aug. 14, 1901, p. 70, pl. 23, figs. 32, 33.

"Shell ventricose. Spire slightly inrolled; the body of the shell rather rapidly expanding to the almost perfectly circular aperture. The concentric striae almost obliterated in silicification of the shell.

The circular outline of the aperture and the slightly curved spire make it easy to identify this species.

The type comes from the Warsaw [Salem] group at Lanesville, Ind., and is in the collection of G. K. Greene.]

[Genus ANOMPHALUS M. & W.

ANOMPHALUS ROTULIFORMIS n. sp.

Plate XXIV, figs. 12-12a.

Shell robust, smooth; spire depressed, scarcely rising above the level of the last volution, slopes continuous with those of the last volution, so that in profile the shell appears uniformly rounded over the apex. Whorls about three in number, inner one very small and expanding very rapidly, so that the outer whorl is much larger than the preceding one (ratio of diameters about 3 to 1). Suture very narrow, but plainly marked. The successive whorls overlap to such an extent and their profiles join each other with such an even curvature that the suture is scarcely depressed below the general level of the surface of the shell. This character distinguishes these shells at once from Straparollus, which they resemble in their low spires and smooth rounded whorls. Aperture round. Umbilicus shallow. This species is very similar to *A. rotulus,* M. and W., but differs somewhat in the profile of the whorls.

Locality.—Spergen Hill, Ind., rare.

Indiana University collection.]

[Genus POLYTREMARIA de Konink.

POLYTREMARIA (?) SOLITARIA n. sp.

Plate XXIV, figs. 6-6a.

A single specimen from Spergen Hill has the following characters: Shell planorbiform, smooth; spire slightly elevated above the level of the outer whorl and having a concave profile. Five volutions; the four inner ones expanding rather slowly, the outer one considerably larger than the next preceding whorl. Suture well defined. The profiles of the volutions are well rounded on the sides, somewhat flattened on top and descending into the sutures with an easy curve. Aperture not exposed. Umbilicus

broad and deep. The feature of this shell that distinguishes it from any other known to the writer from the rocks of this horizon, is the two sinuous lines alternately approaching and receding from each other and occupying the place of the slit-band of the PLEUROTOMARIIDAE. This feature at once distinguishes the shell from *Straparollus spergenensis,* which it otherwise resembles so closely as to make it likely that the species is commonly mistaken for the latter, and that this fact accounts for its not hitherto having been detected.

These sinuous lines on the middle of the whorl represent the margins of the (closed) slit, which alternately approach each other very closely, thus giving rise to a row of perforations similar to those of *Haliotis.* In *Pleurotomaria catenata,* de Konink, the only species with which I can compare this, the coalescence of the slit margins is complete, whereas in the present form they merely approach each other closely. The species is placed provisionally in the genus *Polytremaria.*

Locality.—Spergen Hill, Ind., very rare.

Indiana University collection.]

[Genus GRYPHOCHITON Gray.

GRYPHOCHITON (?) PARVUS (Stevens).

Plate XXIV, figs. 8-8c.

Chiton parvus Stevens, Am. Jour. Sci. (2), Vol. 25, p. 264.

"Anterior valve semi-circular, conical. Apex pointing posteriorly, sloping regularly to the margin. Middle valves acutely sub-rhomboidal, scooped in front, sharp behind, dorsum elevated, terminating posteriorly in an acute apex. Posterior valve semicircular behind, abrupt in front, rising into an acute ridge, extending to the middle of the valve, terminating in an acute apex, from which the valve slopes to the margin, which is thickened and turned up. Accessory plates are more broadly rounded than in the preceding species [*Chiton carbonarius*]. Surface under glass minutely granulated.

"Length.—Plates 0.1 of an inch, shell 1 to 2 inches."

The locality given by Stevens is "Bergen Hill," Indiana, in the "Archimedes limestone." This must certainly mean Spergen Hill. The above description applies very well to specimens in the

Indiana University collection from the Salem limestone at Harrodsburg, Ind. At the latter locality the species is not uncommon. It is also present at Bloomington, Ellettsville, Stinesville and Romona, Ind.]

[Genus ACMAEA Eschscholtz.

Plate XXIV, figs. 6-6a.

The specimens figured are doubtfully referred to this genus.]

PTEROPODA.

Genus CONULARIA, Miller.

CONULARIA SUBLATA Hall.

Plate XXV, fig. 3.

Trans. Alb. Inst., Vol. 4, p. 32.

"Shell quadrangular, the four sides nearly flat and converging at an angle of about 18 degrees; surface marked with a distinct longitudinal groove on each of the angles, and numerous regular, smooth, closely arranged, elevated, transverse striae, which pass a little obliquely downwards towards the middle of each of the sides, where they meet at a very obtuse angle. A single sharp longitudinal line passes down the center of each side, without interrupting the transverse striae; angles truncate or rounded towards the apex.

"Length .50 of an inch."

The striae on this shell, so far as can be determined from the imperfect specimens in the collection, are smooth, and have had no longitudinal striae crossing them, cutting their surfaces into ornaments, as is generally the case in this genus. They are very angular and occupy the entire space of the furrow. The number in a given distance varies with the distance from the apex of the shell, one counting eighteen in a tenth of an inch where the shell measures a twelfth of an inch in diameter, and another where the shell is a trifle less than a sixth of an inch in diameter there are only ten in the same distance. The specimens are too small and imperfect to afford means for comparison with other described forms.

Locality.—Alton, Ill. [This species has not yet been recognized in Indiana.]

[CONULARIA MISSOURIENSIS Swallow.

Trans. St. Louis Acad. Sci., Vol. I, p. 657.

"Shell large, in the form of an elongated four-sided pyramid with a depressed rhombic base. The obtuse lateral edges are marked by deep angular sulcations; the acute lateral edges subcarinated. Surface polished; each of the four sides marked by flexuous, high, sharp plications. There are two sets of plications on each side; they commence on the sides and curve towards the base, then partially back, when they meet or intersect in the middle, forming an indistinct longitudinal sulcation along the middle of each side; the space between the plications is at least twice as wide as the plications. There are ten plications in a space equal to the width of the side where they are situated.

"From the Carboniferous limestone of Cooper County (Missouri)," Swallow, *loc. cit.*

An example of this species in the State Museum of Indiana is labeled from Spergen Hill, but may be from a higher horizon than the Salem limestone. It resembles very closely the specimen figured by Meek and Worthen (Geol. Ill., Vol. V, pl. 22, fig. 5), but has the crenulations on the costæ mentioned by Calvin (Am. Geol., Vol. V, p. 207.]

[CONULARIA GREENEI Miller and Gurley.

Plate XXIV, fig. 14.

Bull. No. 11, Ill. State Mus., p. 27, pl. III, fig. 3.

"Species long, slowly expanding, pyramidal, subquadrated, sides equal, deeply furrowed at the four angles. Longitudinal line in the middle of each side. Surface ornamented with wide, concave, smooth furrows that arch forward from the four angles. These furrows are separated by sharp costæ, generally without crenulations. The costæ sometimes cross the mesial line without interruption, in other cases they terminate alternately at the mesial line. They do not curve forward when bending into the furrows at the four angles, nor do they reach the bottom of the furrows. They alternate in these furrows. The transverse furrows are crossed by a few longitudinal wrinkles, at the margin of the longitudinal furrows.

"There are only thirteen transverse furrows in an inch, where our specimen is eight-tenths of an inch in diameter. The shell of our specimen is horny and has the smooth, hard appearance of the test of a trilobite.

"This species is so different from all that have heretofore been described, from the Keokuk Group, that no comparison with any of them is necessary. It is distinguished by its slender form, wide, transverse, smooth furrows and sharp costæ. There are some slight crenulations on the costæ, toward the larger end of our specimens, but none toward the smaller end." (Miller and Gurley, *loc cit.*)

Mr. G. K. Greene has submitted the specimen figured herein, and which is said to come from Spergen Hill. There is, however, some doubt both as to the horizon and locality. It is quite likely that *C. Greenei* and *C. Missouriensis* will prove to be one species.

CEPHALOPODA.

Genus ORTHOCERAS, Breyn.

ORTHOCERAS EPIGRUS Hall.

Plate XXV, fig. 2.

Trans. Alb. Inst., Vol. 4, p. 33.

"Shell sub-cylindrical, very gradually tapering; section circular; siphuncle small, sub-central; septa slightly concave, separated by spaces equal to about one-third the diameter of the shell; surface marked by distant, rather faint, longitudinal lines."

The only specimen of the species in the collection is a fragment retaining five chambers. The septa are remarkably flat. With a strong hand glass I fail to find any indications of the "rather faint longitudinal lines" spoken of in the original description.

Locality.—Spergen Hill, Ind. [Ellettsville and Harrodsburg, Ind.]

[ORTHOCERAS SP?

Plate XXIV, figs. 13-13a.

The specimens figured are from the collection of Mr. G. K. Greene and were collected at Edwardsville, Ind.]

Genus NAUTILUS.* Breynius.

NAUTILUS CLARKANUS Hall.

Plate XXV, fig. 1.

Trans. Alb. Inst., Vol. 4, p. 32.

"Shell sub-discoidal, flattened on the dorsum and angular at its lateral margin; umbilicus large, showing all the inner volutions; volutions (number unknown) rapidly diminishing, broader than high, not embracing; surface ornamented by a deep, revolving groove around the dorso-lateral margin, between which and the umbilicus is a single row of indistinct nodes, and about five or six strong striae, which are crossed by fine elevated striae. Aperture transversely oval; septa slightly concave, and separated by spaces about equal to one-fourth the greater diameter of the volutions.

"The specimen described is somewhat worn upon the dorsal side, which may have obliterated the fine transverse or longitudinal striae, remaining upon the lateral edge of the shell."

The specimen used for the above description is a fragment of what was a much larger shell, and from its imperfect condition has led to a misconception of the characters of the species. There are three small fragments in the collection, which show that the volutions were not flattened on the dorsum, but that portion which forms the flat surface, and the border of the "deep revolving groove around the dorso-lateral margin" of the volution is only a portion of the inner surface of a succeeding volution which has been broken away, leaving the ventral portion attached to the present one. The dorsal surface has been broadly convex, and so far as seen on the fragments mentioned has been marked by revolving ridges, coarser and more distant than on the side of the volution. None of the specimens show the position of the siphon or afford means of comparison with other species.

Locality.—Spergen Hill, Ind. [Paynters Hill.]

[*In the restricted sense in which the genus *Nautilus* is now used, the present species should not be referred to that genus. The writer can not with the material available, determine its true generic position.]

[Genus TEMNOCHEILUS McCoy.

TEMNOCHEILUS COXANUS M. & W.

Plate XVI, figs. 3, 4.

Proc. Acad. Nat. Sci., Phila., p. 50.

Some specimens from the Indiana State Museum are doubtfully referred to this species.

Locality.—Spergen Hill, Ind.

[TRILOBITA.

Genus GRIFFITHIDES Portlock.

GRIFFITHIDES BUFO M. & W.

Plate XXIV, fig. 4.

Geol. Surv. Ill., Vol. V, p. 528, pl. 19, fig. 5.

"Entire outline elliptical, the breadth being to the length as 75 to 130. Cephalic shield forming more than a semi-circle, round in front and nearly straight behind; posterior lateral angles terminating in short, abruptly pointed spines extending back to the anterior edge of the thoracic segment. Glabella rather depressed convex, wide anteriorly and narrowing posteriorly to the neck furrow, just in front of which, and connected with the palpebral lobes on each side, it has a single small, obscure lateral lobe; neck furrow broad and well defined, both across the glabella and across the posterior margins of the cheeks; neck segment rather wide, depressed below the level of the highest part of the glabella in front of it. Eyes of moderate size, reniform, nearly as prominent as the glabella, placed but little in front of the continuation of the neck furrow across the cheeks, apparently smooth, but showing when the outer crust is removed, numerous very minute lenses beneath. Cheek sloping off rather abruptly from the eyes of the thickened margin, which does not continue around the front of the glabella; facial sutures cutting the anterior margin in front of the eyes before, and a little outside of them behind. Thorax nearly twice as wide as long, distinctly trilobate; mesial lobe but moderately prominent, nearly twice as wide as either of the lateral lobes, its eight segments merely rounded, and without furrows. Lateral lobes narrow; pleurae curving moderately downwards at less than half their length out from the axial lobe, but not dis-

tinctly geniculated, each provided with a furrow extending nearly half way out. Pygidium approaching semi-circular, with the anterior lateral angles obliquely truncated; mesial lobe but slightly wider anteriorly than the lateral; segments about eleven; lateral lobes with eight or nine segments. Surface finely granular, the granules being most distinct on the glabella, and the segments of the mesial lobes of the thorax.

* * * * * * * * *

Locality and Position.—Crawfordsville, Ind.; Keokuk division of the Lower Carboniferous series." (Meek and Worthen, *loc. cit.*)

[The Indiana University collections contain specimens from Harrodsburg, Bloomington, Spergen Hill and Stinesville, in the Salem limestone.]

TABLE SHOWING THE OCCURRENCE AND RELATIVE ABUNDANCE OF FOSSILS FROM VARIOUS LOCALITIES OF THE SALEM LIMESTONE.

The table is intended to represent the occurrence and relative abundance of the species of this horizon at each of the principal localities studied. Owing to necessary haste in finishing this paper for the volume in which it must appear the table is consequently incomplete, as pointed out below. The statistics are based on collections studied in the preparation of the report.

The collections were made from Paynters Hill, Spergen Hill, Harrodsburg, Bloomington, Ellettsville and Stinesville (Big Creek quarries) by shipping in large quantities of highly fossiliferous material and working it up in the laboratory. It consisted of both the solid rock and the disintegrated material. From the latter the fossils were selected by washing.

The table is probably most complete for Harrodsburg, Ellettsville and Stinesville. Only incomplete collections have been studied from Lanesville and many of the characteristic species are wanting, probably for the same reason that they are not found at Paynters Hill, as before stated, where the same conditions exist.

Large amounts of material are on hand from Spergen Hill, but only a portion of this fauna has been carefully studied, for lack of time, so that the relative abundance can not be accurately given. The characteristic fauna, as represented in Hall's original collec-

tion is present here, however, in about the same proportion as at Harrodsburg, except that the number of species is greater and the material is in a better state of preservation.

So far only collections of Brachiopoda and Bryozoa have been made from Bedford. Further collecting will probably reveal the characteristic gastropods and other forms in favorable places. At Harrodsburg the fauna is very much dwarfed. A portion of the upper part of the stratum is highly fossiliferous, with the characteristic species of gastropods, brachiopods and pelecypods, but conditions were not such as to develop the large brachiopods as at Bedford. The specimens are usually somewhat water-worn and coated with lime.

The collection from Bloomington is only moderately complete. As a rule the fossils are hard to secure from this region, few being well preserved, save in pockets and occasional bedding planes. The table is fairly complete for Stinesville and Ellettsville. At Romona, the northernmost locality studied, as stated before, there is but a limited fauna.

EXPLANATION OF CHARACTERS USED IN THE TABLE.

rr, very rare; r, rare; c, common; a, abundant; aa, extremely abundant (600 to 10,000 specimens); + rr to c, or thereabouts. This last character is only used when the actual number of specimens in the collection has not been ascertained.

The crinoids are usually designated as very rare, as good specimens are very hard to secure. Some of the species recorded from this horizon are not found so far in the nine localities given. They are included in the table so that it will be as nearly a complete a list as practicable at present. In such cases, of course, there will be no locality indicated in the table, but it will be found in the text.

	Lanesville.	Paynter's Hill.	Spergen Hill.	Bedford.	Harrodsburg.	Bloomington.	Elletsville.	Stinesville.	Romona.
1. Endothyra baileyi		a	aa		aa		?	c	r
2. Amplexus blairi									
3. Bordenia zaphrentiformis	r	c	r						
4. Ceratopora agglomerata	+								
5. Cyathaxonia venustum	rr	c	r						
6. Cystelasma lanesvillensis	a	r	r			rr			
7. Cystelasma rugosum		r	rr						
8. Cystelasma septatum	c	rr	r						
9. Cystelasma tabulatum			rr						
10. Enallophyllum grabaui	c	?	?						
11. Michilinia indianensis	rr					rr			
12. Monilopora beecheri	aa	aa	c	c					
13. Palaeacis cuneiformis		c	c						
14. Syringopora monroensis	rr					c			
15. Zaphrentis cassedayi	aa	aa	aa	c	a	c	c		
16. Zaphrentis clinatus									
17. Zaphrentis compressa	c	a	a						
18. Batocrinus calyculus			rr						
19. Batocrinus crassitestus	rr								
20. Batocrinus davisi	rr								
21. Batocrinus davisi lanesvillensis	rr								
22. Batocrinus davisi sculptilis	rr								
23. Batocrinus icosadactylus	r	r	r						
24. Batocrinus irregularis	r	r	r						
25. Batocrinus magnirostris	rr								
26. Batocrinus sacculus			rr						
27. Batocrinus salemensis									
28. Dichocrinus blatchleyi		r							
29. Dichocrinus oblongus						rr			
30. Dichocrinus sp		rr							
31. Dichocrinus striatus?	rr	r			rr				
32. Dizygocrinus decoris			rr						
33. Dizygocrinus euconus			rr						
34. Dizygocrinus sp.		c	c						
35. Dizygocrinus unionensis	rr								
36. Dizygocrinus whitei	r	?	?						
37. Forbesiocrinus sp.		c	c						
38. Icthyocrinus clarkensis									
39. Platycrinus bonoensis									
40. Platycrinus boonvillensis	c	r	r						
41. Platycrinus sp		r							
42. Poteriocrinus coryphaeus		rr							
43. Symbathocrinus swallowi	a	+	+						
44. Talarocrinus simplex	+	c	r			rr			
45. Talarocrinus Cf. trijugus	rr								
46. Pentremites conoideus	aa	a	a	+	a	a	a	a	r
47. Pentremites conoideus amplus	+								
48. Pentremites conoideus perlongus	+								
49. Tricoeloerinus meekiana	rr	rr		rr		rr			
50. Troostocrinus wortheni	c	c							
51. Archaeocidaris norwoodi		c	r						
52. Holothurian? spicules		rr	rr			rr			
53. Ortonia blatchleyi				rr					

	Lanesville.	Paynters Hill.	Spergen Hill.	Bedford.	Harrodsburg.	Bloomington.	Elletsville.	Stinesville.	Romona.
54. Spirorbis annulatus		r	c	rr	c	rr	rr	rr	r
55. Spirorbis imbricatus		+	rr	rr					
56. Spirorbis nodulosus		rr	+		rr				
57. Cystodyctia lineata	c	c	a			c		a	
58. Cystodyctia ocellata		c		r		a	a	aa	
59. Dichotrypa flabellum	c	a	a	?		r			
60. Dichotrypa sp								r	
61. Fenestella compressa elongata				c					
62. Fenestella exigua				r-c					
63. Fenestella multispinosa bedfordensis	?	?	?	aa		c		+	
64. Fenestella rudis major				c		?			
65. Fenestella serratula				cc		c	+	+	
66. Fenestella serratula quadrata				a					
67. Fenestella serratula perversa				r					
68. Fenestella tenax mumtinodosa				rr					
69. Fenestella nodosa				a		c		+	
70. Fenestella tenuissima				rr					
71. Fenestralia sanctiludovici			+	r		+			
72. Fenestralia sanctiludovici compacta				c					
73. Fistulipora spergenensis	a	a	a	r		r		r	
74. Fistulipora spergenensis minor				r					
75. Fistulipora sp				rr				r	
76. Glyptopora michelinia				r		r			
77. Hemitrypa beedei				r		r-c			
78. Hemitrypa plumosa			?						
79. Hemitrypa proutana	+	+	+	r-c		c			
80. Hemitrypa proutana nododorsalis				c					
81. Pinnatopora? sp				rr					
82. Polypora biseriata				r					
83. Polypora internodata				r		r			
84. Polypora maccoyana				r		?			
85. Polypora simulatrix	?	?	+	c		c			
86. Polypora spiniodata				rr					
87. Polypora striata				r		r			
88. Rhombopora bedfordensis				c	c	a	a	a	
89. Rhombopora sp				r		r	r	r	
90. Stenopora rudis				r-c					
91. Stenopora tuberculata			?						
92. Stenopora sp				c		c			
93. Worthenopora spinosa				rr		r		c	
94. Worthenopora spatula				rr					
95. Athyris densa	c		c						
96. Camarophoria subcuneata	c		r	c	c		r	c	c
97. Centronella?? crassi cardinalis			rr						
98. Cleiothyris hirsuta	a		c	a	c		r	c	r
99. Dielasma formosa	+	c	+	rr	a	+	c	c	c
100. Dielasma gorbyi									
101. Dielasma turgidum	a	c		c	c	rr	a	c	
102. Eumetria marcyi	a	r		c	aa	+	a	a	rr
103. Orthothetes minutus	rr			r	c	c	+	rr	
104. Productus biseriatus				c	+	c	rr	rr	
105. Productus burlingtonensis? var									
106. Productus gallatinensis									
107. Productus indianensis	r	rr	c	r	+	r			
108. Pugnax grosvenori	a	c		c	c	c	c		c
109. Pugnax? quadrirostris					rr			rr	
110. Reticularia pseudolineata			r	c		+			
111. Reticularia setigerus				rr					
112. Rhipidomella dubia	a		c				c		
113. Rhynchonella ricinula			+		c				
114. Rhynchonella mutata							rr	r	c
115. Seminula trinuclea	a	c	rr		r		r	+	
116. Spirifer bifurcata	c	c	+	c	r	c	rr	c	r
117. Spirifer horizontalis	+								
118. Spirifer lateralis delicatus	+								
119. Spirifer sp									
120. Spirifer subaequalis	rr	?							
121. Spirifer subcardiiformis				rr					
122. Spirife suborbicularis	rr			rr					
123. Spiriferina norwoodana	+		c	c	r	+			
124. Conocardium carinatum			+		rr	+			

		Lanesville.	Paynters Hill.	Spergen Hill.	Bedford.	Harrodsburg.	Bloomington.	Elletsville.	Stinesville.	Romona.
125.	Conocardium catastomum	....	....	+	....	c	+	r	c	rr
126.	Conocardium cuneatum	...	....	+	....	r	+	....	c	....
127.	Conocardium prattenanum	....	....	....	....	rr	....	....	....	....
128.	Cypricardinia indianensis	+	rr	+	+	+	r	c	c	....
129.	Edmondia? subplana	+	....	+	....	cc	rr	....	....	c
130.	Goniophora? plicata	....	....	+	....	....	+	....	c	....
131.	Macrodon sp	....	....	rr	....	....	....	....	....	....
132.	Microdon ellipticus	....	....	+	....	....	....	....	....	....
133.	Microdon oblongus	....	rr	+	+	c	rr	rr	c	rr
134.	Microdon subellipticus	....	....	+	....	c	rr	rr	r	....
135.	Nucula shumardana	....	....	+	....	c	c	c	a	a
136.	Nuculana nasuta	....	....	+	....	....	....	rr	rr	rr
137.	Pteronites spergenensis	....	....	+	....	rr	rr	rr	....	....
138.	Acmaea? sp	rr	....	...	....	....	....	....	....	....
139.	Anomphalus rotuliformis	....	....	rr	....	....	....	....	....	....
140.	Bellerophon gibsoni	....	....	....	+	....	+	+	....	....
141.	Bellerophon sp	....	rr	....	....	....	....	....	....	...
142.	Bellerophon sublaevis	....	+	+	....	r	+	a	c	....
143.	Bembexia elegantula	....	....	+	....	....	+	....	rr	....
144.	Bucanopsis textilis	....	r	+	....	c	+	r	c	....
145.	Bulimorpha bulimiformis	....	rr	+	....	c	c	c	c	rr
146.	Bulimorpha canalicula a	+	....	+	....	....	....	....	....	....
147.	Bulimorpha elongata	+	....	+	....	....	....	....	....	....
148.	Coeloconus sp	....	....	....	?	?	....	...	....	...
149.	Conularia greenei	....	....	?	....	....	....	....	....	....
150.	Conularis missouriensis	....	....	?	....	....	....	....	....	....
151.	Cyclonema leavenworthana	....	....	+	....	a	a	a	aa	r
152.	Eotrochus concavus	....	....	rr	+	....	....	....	....	rr
153.	Glyptochiton? parvus	....	....	....	....	c	rr	rr	r	rr
154.	Holopoea proutana	....	rr	+	....	a	a	c	a	c
155.	Loxonema yandallana	....	....	+	....	r	....	....	r	r
156.	Machrocheilus littonanus	....	....	....	....	....	+	....	....	....
157.	Macrocheilus stinesvillensis	....	....	...	....	....	...	....	+	....
158.	Murchisonia littonana	....	....	+	+	a	c-a	c	a	rr
159.	Murchisonia sp	....	....	rr	....	....	....	....	....	....
160.	Murchisonia terebriformis	....	....	....	....	c	+	rr	c	rr
161.	Murchisonia vincta	....	...	+	....	c	....	....	c	rr
162.	Orthonychia acutirostre	c	r	r	r	....	...	....	....	rr
163.	Pleurotomaria conula	....	rr	+	....	c	....	r	c	r
164.	Pleurotomaria meekana	....	....	?	....	rr	....	c	c	....
165.	Pleurotomaria nodulostriata	+	....	+	....	rr	....	r	c	....
166.	Pleurotomaria piazaensis	....	rr	....	....	....	....	rr	c	....
167.	Pleurotomaria subglobosa	....	....	+	....	c	r	rr	c	rr
168.	Pleurotomaria swallowana	....	rr	+	....	....	rr	r	c	...
169.	Pleurotomaria trilineata	....	....	+	....	rr	+	rr	r	rr
170.	Pleurotomaria wortheni	....	....	+	....	....	rr	....	....	....
171.	Polytremaria solitaria	....	....	rr	....	....	....	....	....	....
172.	Soleniscus glaber	....	...	r	....	....	....	....	....	....
173.	Solenospira attenuata	....	rr	+	...	c	rr	c	rr	r
174.	Solenospira turritella	....	rr	+	...	a	c	....	a	c
175.	Solenospira vermicula	....	rr	+	....	a	r	r	c	r
176.	Strophostylus carleana	..	....	+	...	c	+	c	a	rr
177.	Straparollus spergenensis	....	c	aa	...	aa	c	aa	aa	c
178.	Subulites harrodsburgensis	....	....	....	....	aa	r	....	rr	....
179.	Nautilus clarkanus	....	rr	rr	....	....	....	....	....	....
180.	Orthoceras epigrus	....	....	rr	....	....	....	rr	....	....
181.	Orthoceras sp	rr	....	....	....	....	....	....	....	....
182.	Temnocheilus sp	....	....	+	....	....	....	....	....	....
183.	Cephalopod sp (Nautilus)	....	....	+	....	....	....	....	....	....
184.	Griffithides bufo	...	....	....	....	rr	....	rr	....	....
185.	Leperdita carbonaria	....	....	....	....	c	c	c	a	c
186.	Leperdita sp	....	....	....	....	rr	....	....	....	....
187.	Cytherellina glandella	....	....	....	....	rr	....	c	c	c
187.	Ostracod sp	....	....	....	....	rr	....	....	....	....

FISH REMAINS FROM THE SALEM LIMESTONE OF INDIANA.

E. B. Branson.

At the request of Dr. J. W. Beede of the Indiana Geological Survey the writer has prepared this report on the fish remains from the Salem limestone. The material at the writer's disposal was a collection belonging to Mr. G. K. Greene, a few specimens from the American Museum of Natural History, a small collection belonging to the University of Indiana, and several specimens from Walker Museum, University of Chicago. The writer is under obligations to Dr. Stuart Weller for the use of the collection from Walker Museum.

CLADODUS FEROX Newberry and Worthen.

Plate XLI, Figs. 3 and 4.

Cladodus ferox Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 26, pl. 1, fig. 11.

Teeth of large size, breadth greater than height; base semi-elliptical, with a shallow sinus in front, smooth throughout; median cone slightly curved backward, conical with a circular section, finely and evenly striated longitudinally; lateral denticles about five on either side; exterior pair one-third the height of the principal cone, conical, acute, striated throughout, divergent from median cone and strongly curved backward; intermediate denticles about four on either side, largest half the size of the exterior pair, conical, striated, projecting forward.

The teeth of this species vary considerably. The base varies from about twice as long as broad to about two and one-half times as long as broad; the central cone sometimes occupies two-sevenths the space of the anterior part of the base and sometimes not more than one-fifth. Besides the five main denticles on either side, there are four or five minute denticles located between the anterior edges of the others or on the antero-lateral part of their bases. The outermost is the largest of the lateral denticles, the third next largest.

It seems probable that the teeth named *C. stenopus* Newberry and Worthen belong to this species. Both species were described from imperfect teeth and the writer has studied several teeth from Lanesville, Indiana, that may be referred to either species with equal correctness.

CLADODUS SPINOSUS Newberry and Worthen.

Plate XLI, Figs. 1-2.

Cladodus spinosus Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 22, pl. 1, fig. 3.

Teeth of medium or large size, broader than high; base representing a little more than half of an imperfect hexagon, with the posterior side slightly longer than the others; thick, with a sharpish edge behind, before strong beveled under and scooped out in a shallow sinus beneath the median cone; whole anterior border of base, above the smooth beveled edge, set with many minute spines directed upward; these spines cover the anterior bases of all the lateral denticles, and the antero-lateral edges of the base of the principal cone. Median cone conical, somewhat curved backward, rapidly tapering to an acute point; lower portion with a nearly circular section, finely and evenly striated longitudinally, near the point smooth, compressed, with cutting edges; lateral denticles 6-7 on either side, conical, striated and curved backward, exterior pair much larger than intermediate ones.

Formation and Locality.—Salem limestone, Salem, Indiana; St. Louis limestone, St. Louis, Missouri.

CLADODUS INDIANENSIS sp. nov.

Plate XLII, Figs. 5-8.

Teeth small to medium size. Base almost straight in front, rounded at the ends, gently convex behind; inferior surface smooth, slightly concave in middle; superior surface flat in a narrow area behind the median cone, thence convex to the edges. Median cone low, large, subcircular in transverse section near the base, lateral cones one on each side, very close to the median but much smaller; a small denticle at the angle where the lateral and median cones meet; cones without markings of any kind save weak costae at the antero-lateral angles of the main cone.

Formation and Locality.—Salem limestone, Paynter's Hill and Lanesville, Indiana.

CLADODUS STRIATUS sp. nov.

Plate XLII, Figs. 1-4.

Teeth of medium size, base of type specimen 14 mm. wide by about 5 mm. long, tooth broader than high. Outline of base subelliptical, extremities subangular, posterior border with stronger convexity than anterior; under surface smooth, upper surface with a narrow furrow just behind the cones running parallel with the posterior margin of base, a strong ridge between this furrow and the posterior margin. Middle cone low, broad and thin near base, twice as broad as thick, with sharp cutting edges; outer lateral denticles broad, thin and very low, one-third to one-fourth height of median cone; between lateral denticles and median cone a high narrow ridge that bears two-minute denticles on one side of the median cone but none on the other side in the type specimen; median cone and lateral denticles all marked with almost vertical, narrow, sharp-crested ridges, spaces between ridges about twice as broad as ridges.

C. striatus differs from *C. euglyphaeus*, the nearest allied species, in its much larger size, much greater breadth of median cone, greater breadth and less height of outer lateral denticles, smaller number of lateral denticles, high ridge between outer denticles and main cone, and in the greater approximation of the ridges on the teeth.

Formation and Locality.—Salem limestone, Paynter's Hill, Ind.

Type specimen No. 7709-1 American Museum of Natural History.

CLADODUS LAMNOIDES Newberry and Worthen.

Plate XLII, Figs. 9 and 10.

Cladodus lamnoides Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 30, pl. 1, fig. 16.

Teeth small, base narrow, straight before, arched behind, relatively thin, smooth; median cone narrow, conical, recurved, slightly rounded before, strongly so behind, very acute at point, with cutting edges that extend to near the base; anterior surface smooth; posterior face finely striated longitudinally; lateral denticles two or four, outer one one-fourth the length of the principal cone.

Formation and Locality.—Salem limestone, Edwardsville, Floyd County, Indiana; Keokuk limestone, Warsaw and Nauvoo, Illinois. Trautschold reports this species from Russia.

CLADODUS sp. undescribed.

Plate XLII, Fig. 11.

A fragment of tooth of *Cladodus* from Lanesville represents an undescribed species, but is too imperfect for specific description. It differs from *Cladodus ferox* in the greater breadth of the central cone, in the large size of the outer lateral denticles, in having only three lateral denticles, in the shortness of the base on either side of the median cone, in the thickness of the base and in the presence of prominent bosses on the anterior edge of the base below the space between the median cone and outer denticles.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

PETALODUS LINGUIFER Newberry and Worthen.

Plate XLI, Figs. 13-15.

Petalodus linguifer Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 37, pl. 2, figs. 4-5.

Teeth large, broader than high; crown three times as broad as high, cutting edge broadly and nearly evenly arched, finely crenulated, anterior surface highly polished, root smooth, tongue-shaped, rounded below, posterior face equal in height to posterior face of crown, anterior face one-third the higher.

Formation and Locality.—Salem limestone, Edwardsville, Salem, Paynter's Hill and Lanesville, Indiana; Chester limestone, Chester and Pope County, Illinois, and Missouri.

CHOMATODUS PARALLELUS St. John and Worthen.

Chomatodus parallelus, St. John and Worthen, 1875, Paleontology of Illinois, Vol. 6, p. 358, pl. 10, figs. 3-4.

Teeth of medium or small size laterally elongated, with the upper and lower margins subparallel. Crown symmetrical, more or less compressed and sharp-crested, rounded at the extremities. The convex face equals in elevation half the entire height of the tooth, plane or slightly arched vertically, nearly straight laterally,

with a narrow coronal belt consisting of two or three imbrications. The concave face is occupied by a rather deep lateral depression, and bordered by three or four well-marked imbricating folds, which are gently curved upward at the extremities where they are confluent with the folds of the opposite face. The crest and basal margins are for the greater extent horizontal and parallel and in the perfect condition the crown is enveloped in a coating of enamel, which is usually more or less distinctly striated vertically. In worn specimens the crest is denticulate, due to its porous character. The base is thick and strong, nearly perpendicular to the crown, inferior surface relatively wide and obliquely beveled from the concave side to the opposite margin, the convex face nearly plane and vertically furrowed, the shallower concave face deeply channeled beneath the produced coronal margin. Length of tooth about 16 mm., height 5 mm.

In a specimen from Lanesville the crown gradually decreases in height from one end to the other, so that the height of the entire tooth is five millimeters at one end, a little more than four at the other.

Formation and Locality.—Salem limestone, Lanesville, Indiana; Warsaw limestone, Missouri and Illinois.

CHOMATODUS INCONSTANS St. John and Worthen.

Plate XLI, Figs. 29-31.

Chomatodus inconstans St. John and Worthen, 1875, Pal. Ill., Vol. 6, p. 360, pl. 10, figs. 5-14.

Chomatodus varsouvinensis St. John and Worthen, 1875, Ibid., p. 363, pl. 10, figs. 1-4.

Chomatodus chesterensis St. John and Worthen, Ibid., p. 363, pl. 10, figs. 15-17.

The teeth of this species vary greatly. The largest specimen examined during the present investigation is 22 mm. long, 12 mm. wide and 10 mm. high, while the smallest is 10 mm. long and 5 mm. wide at the widest part. In some of the teeth the longer sides are nearly parallel, while in others the broader end is more than twice as wide as the narrower. In some specimens the central ridge of the crown is high at one end and decreases in height until it is low at the other, while in other specimens the ridge

is nearly the same height the entire length of the tooth. The root of some of the teeth is nearly vertical, while in others it is oblique.

Formation and Locality.—Salem limestone, Lanesville and Paynter's Hill, Indiana, Illinois and Missouri; Chester group, Illinois, and Keokuk group, Iowa.

CHOMATODUS LANESVILLENSIS sp. nov.

Plate XLII, Figs. 15-18.

Type a single imperfect tooth. Tooth of medium size; crown low, convex side narrow, marked by two or three narrow ridges running parallel to the rounded edge. Concave surface pointed at one extremity, broadening rapidly until nearly twice as wide as convex surface, marked by oblique imbricating ridges, edge acute. Root narrow, short, sides parallel for about half the length, thence strongly imbeveled from concave side, rounded inward from convex side to form acute lower edge.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

HELODUS LAEVIS Newberry.

Plate XLI, Figs. 16-22.

Helodus laevis Newberry, 1879, Geological Survey of Indiana, p. 343.

Teeth small, 20 to 25 mm. long, 4 to 5 mm. broad and high; outline linear, slightly curved or straight, crown surface arched from front to rear; uniformly smooth and polished, but finely punctate. Root as high as crown, flat below and on the sides, as broad as high, slightly oblique. Seen from above these teeth resemble those of *Helodus angulatus* N. and W.,* but differ from them in the shape of the root and in the pores on the enameled surface not being elongated.†

Formation and Locality.—Salem limestone, Lanesville, Spergen Hill, Edwardsville, Romona and Harrison County, Indiana.

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*Paleontology of Illinois, Vol. 2, Pl. 5, Figs. 9-15.

†St. John and Worthen consider *Helodus angulatus* as a variety of *Chomatodus inconstans*, Paleontology of Illinois, Vol. 7, p. 362.

HELODUS CONICULUS Newberry and Worthen.

Plate XLI, Figs. 5-7.

Helodus coniculus Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 75, pl. 14, figs. 19, 19a.

Teeth small, laterally short, crown composed of a relatively high, rounded, central cone, with short lateral appendages. A sulcus surrounds the crown constricting it, at its junction with root; root nearly as broad as crown, oblique, its vertical face deeply impressed with vermicular cavities; the crown surface is smooth and polished, and uniformly porous throughout.

In the collections from Indiana examined by the writer only one specimen of this species is present. In this specimen the cone is more nearly conical and the lateral appendages slightly longer than in the type.

Formation and Locality.—Salem limestone, Lanesville and Harrison County, Indiana; Burlington limestone, Iowa; Keokuk limestone, Illinois.

HELODUS INCISUS Eastman.

Plate XLI, Figs. 10-12.

Helodus incisus Eastman, 1903, Bull. Mus. Comp. Zool. Harvard College, Vol. 39, p. 204, pl. 5, fig. 54, 54a, 54b.

Teeth small, bilaterally symmetrical, more or less triangular in cross section, the crown rising abruptly into a slightly recurved median eminence, coronal surface uniformly smooth; posterior face strongly convex, anterior face very gently arched almost plane, with a long v-shaped incision; faint ridges extend along the border of the cavity on either side, and a third extends vertically from the angle where they meet to the coronal apex. Lateral expansion of crown short.

The writer has examined a single specimen of this species from Lanesville, Indiana. The tooth is smaller than the type and the apex is more strongly recurved.

Formation and Locality.—Salem limestone, Lanesville and Salem, Indiana.

HELODUS ROBUSTUS sp. nov.

Plate XLII, Figs. 22-24.

Tooth about 14 mm. broad by 10 mm. long, central cone very large, rounded, low, almost flat on top, lateral appendages very

small, rounded or angular, projecting about one-fourth the diameter of cone. A deep sulcus surrounds the crown, restricting it from the root. Root nearly as high as the cone, and as broad as the crown, its vertical face deeply impressed with vermicular cavities. The crown surface is smooth and polished, evenly and finely punctate throughout.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

HELODUS sp. indet.

Among the specimens from Lanesville there is part of a crown of an *Helodus* tooth about the size of that of *Helodus coniculus,* but differing considerably from that form in shape and height. It probably belongs to an undescribed species.

HELODUS ELEGANTULUS sp. nov.

Plate XLII, Figs. 27-29.

Type a single imperfect specimen. Teeth of medium size, the crown rising gradually into a low, broadly rounded eminence. Coronal surface smooth, excepting near the edge, where there are several small imbricating folds running parallel with the edge, punctate on the smooth surface with punctae slightly elongated. One edge of tooth straight, the other slightly convex. Ends straight, oblique, slightly narrower than middle. Root short, thick and strong, nearly as broad as crown. Root much worn in type specimen.

The teeth of this species will be readily distinguished from all other helodoid teeth by the imbricating folds of enamel on the crown, and by the shape of the crown.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

HELODUS ORNATUS sp. nov.

Plate XLII. Figs. 38-40.

Teeth very small, median cone relatively large, subacute. Anterior edge of tooth rounded, posterior edge straight. Root very low. A small tuberculate ridge passes from one end of the tooth to the other just behind the middle. Surface of tooth smooth; punctae in surface minute.

This little tooth resembles those described by St. John and Worthen as *Cochliodus leidyi* but that form lacks the tuberculate ridge of the present species.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

HELODUS(?) MINUTUS sp. nov.

Plate XLII, Figs. 32-34.

Teeth very small, oval in outline, crown surface uniformly rounded, not punctate. Root short, constricted below crown, excavated in middle, appearing as a ring with a diameter slightly less than that of the crown.

These peculiar little teeth were probably associated with larger teeth in the jaw of the fish, but since it is impossible to determine with which teeth they were associated they are provisionally given specific rank.

Formation and Locality.—Salem limestone, Lanesvile, Indiana.

SANDALODUS OCCIDENTALIS Leidy.

Plate XLI, Fig. 33.

Cochilodus occidentalis Leidy, 1857, Transactions of the American Philosophical Society (2), Vol. 11, p. 88, pl. 5, figs. 3-16.

Deltodus stellatus Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 97, pl. 9, fig. 2 (not fig. 3).

Deltodus complanatus Newberry and Worthen, 1866, Ibid., p. 98, pl. 9, fig. 4; Newberry, 1897, Transactions of the New York Academy of Science, Vol. 16, p. 298, pl. 24, figs. 1-7.

Deltodus occidentalis St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 150, pl. 9, fig. 9 (not fig. 10); Eastman, 1903, Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. 39, p. 200, pl. 4, fig. 38, pl. 5, fig. 53.

Deltodus intermedius St. John and Worthen, 1883, Op. cit., p. 153, pl. 9, figs. 14 and 15.

Sandalodus complanatus St. John and Worthen, 1883, Ibid., p. 184, pl. 12, figs. 1-4; Eastman, 1903, Op. cit., p. 198.

Sandalodus occidentalis Branson, 1905, Journal of Geology, Vol. 13, p. 26-29, pl. 1, figs. 8 and 9.*

*In this article the writer incorrectly gives Deltodus complanatus, Newberry and Worthen, Paleontology of Illinois, Vol. 4, Pl. 3, Figs. 5, 8 and 12, as synonymous with *Sanalodus occidentalis*.

Teeth triangular in outline. In teeth of average size, 50-60 mm. long, postero lateral border about 1 cm. longer than antero-lateral. The outer end terminates in an acute point; the inner end has the inner angle obtuse, the outer angle acute. Tooth slightly arched longitudinally and transversely, but, as compared with associated species, flat and thin. A low, broad ridge extends from the obtuse angle of the inner end to the outer end. From this ridge the surface declines very rapidly to the thin antero-lateral border and gently toward the postero-lateral border. Alation broad, slightly upturned. Enameled surface smooth and polished, everywhere finely punctate. Antero-lateral border not modified for articulation with other teeth.

Formation and Locality.—Salem limestone, Paynter's Hill and Salem, Indiana, and Burlington, Keokuk and St. Louis group, Iowa and Illinois.

SANDALODUS LAEVISSIMUS Newberry and Worthen.

Sandalodus laevissimus Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 104, pl. 10, figs. 6-8.

Sandalodus grandis Newberry and Worthen, 1866, Ibid., p. 105, pl. 10, fig. 9.

Deltodus grandis Newberry and Worthen, 1866, Ibid., 105, pl. 9, fig. 9.

Psammodus? rhomboideus Newberry and Worthen, 1866, Ibid., p. 110, pl. 11, fig. 6.

Deltodus grandis J. S. Newberry, 1879, Annual Report of the Geological Survey of Indiana, p. 344.

Sandalodus laevissimus St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 186, pl. 12, figs. 8, 9 and (5 ?)

Deltodus grandis Newberry, 1897, Trans. New York Academy of Science, Vol. 16, p. 297.

Sandolodus laevissimus St. John, 1902, American Naturalist, Vol. 36, p. 659.

Sandalodus laevissimus Eastman, 1903, Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. 39, p. 196.

Teeth of large size, sometimes 5 inches in length by 2 inches in breadth, sub-triangular in outline, strongly arched transversely and longitudinally, with strong spiral inrollment at outer extrem-

ity. Antero-lateral border considerably shorter than postero-lateral, slightly concave; inner margin gently and regularly concave. Surface punctation minute and crowded.

Formation and Locality.—Salem limestone, Lanesville and Harrison County, Indiana; Keokuk group, Illinois, Iowa and Missouri.

SANDALODUS CONVOLUTUS sp. nov.

Plate XLII, Figs. 42-45.

Type a single tooth with inner end missing. Tooth large, thick and strong, outer end with strong incurling as in *S. laevissimus,* but with the curved part forming only half a circle. A broad, high ridge, with a broad, shallow groove at the top, passes from the outer incurved part diagonally across the tooth to the postero-lateral angle, groove less pronounced on the posterior part of the ridge. Surface posterior to ridge convex to the sharp postero-lateral border. Surface in front of ridge descending abruptly and thence sloping gradually to the thin rounded antero-lateral border. Enameled surface finely punctate throughout. Inner end of tooth missing.

This species will be readily distinguished from any other of this genus by the high grooved ridge.

Formation and Locality.—Salem limestone, Bedford, Indiana.

SANDALODUS PORCATUS Branson.

Plate XLI, Fig. 26.

Sandalodus porcatus Branson, 1905, Journal of Geology, Vol. XIII, p. 30, pl. 1, fig. 14.

Length of tooth along antero-lateral edge 34 mm.; breadth above alation 14 mm.; greatest thickness 10 mm. Tooth very thick and strong at the inner end, but becoming thin along the antero-lateral border near the outer end. The postero-lateral border is thick from the outer end to the alation, but becomes quite thin along the margin of the alation. The alation resembles that of *S. emarginatus* in being convex upward and very thick and strong. It occupies considerably more than half the postero-lateral border of the tooth, and diverges from this border at an angle a little greater than 100 degrees. Tooth strongly arched longitud-

inally and transversely, excepting at the outer end, where the transverse arching is much less than in *S. laevissimus* and *S. emarginatus*. The transverse arching near the inner end is much stronger than in any other species of *Sandalodus*. The outer end was probably inrolled as much as in *S. laevissimus*. Enamel punctation so fine that it can with difficulty be detected with the naked eye. The tooth is peculiar in having a sharp ridge along the higher part running from the outer end to the inner. From the antero-lateral border six small ridges with sharp crests pass upward and forward joining the large ridge at the top. The posterior one of these ridges is quite strong, but they decrease in size progressively toward the anterior end of the tooth, and the anterior one is very faintly marked. No lines of growth are present.

Formation and Locality.—Salem limestone, Salem, Indiana.

Note.—Neither the original figure of this tooth nor the one in this article show the strong ridge along the top of the tooth.

PSEPHODUS LATUS? St. John and Worthen.

Plate XLI, Fig. 23.

Psephodus latus St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 72, pl. 2, figs. 1-3.

St. John and Worthen include several forms of teeth in this species, and one tooth from Ellettsville, studied by the writer, seems to belong here. The teeth described by St. John and Worthen are probably posterior mandibular or maxillary rather than mandibular median.

The tooth from Ellettsville is posterior mandibular or maxillary. Tooth small, inner margin straight, posterior margin broadly rounded, outer margin short, slightly convex, anterior margin short, straight, meeting the outer margin at an angle of about 60 degrees. Tooth considerably arched in both directions, summit of arching running parallel with and near the inner margin. Punctate small and remote.

Formation and Locality.—Salem limestone, Ellettsville, Indiana, and St. Louis limestone, Illinois and Missouri.

PSEPHODUS(?) sp. indet.

Among the specimens from Lanesville there is a small imperfect tooth that resembles closely the teeth of *Psephodus latus* in

shape and size, but the punctae are larger and closer together than in the teeth of that species. It probably represents an undescribed species of *Psephodus*. Tooth too imperfect for specific description.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

PSEPHODUS REGULARIS St. John and Worthen.

Plate XLI, Fig. 32.

Taeniodus regular St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 77, pl. 13, fig. 11.

Posterior teeth large, subrhomboidal in outline, moderately arched in the direction of enrollment, antero-lateral border very oblique in its forward and outward course, postero-lateral border almost parallel with it. Inner margin broadly arched from the subacute posterior angle round the base of the coronal prominence, thence with a slight concavity on the way to the obtuse anterior angle. Two-thirds or more of the coronal surface is occupied by a posterior prominence which is gently and regularly arched transversely, the anterior slope descending into the very shallow concavity of the anterior portion of the crown, which is abruptly truncated at the articular border. Greatest breadth of tooth across the inner margin 45 mm., length of anterior border to point of enrollment about 22 mm., nearly two-thirds that of the postero-lateral border. Punctae small and uniform save in the axes of the transverse furrows, where they often present irregular elongate orifices.

Formation and Locality.—Salem limestone, Bedford and Lanesville, Ind.

DELTODUS SPATULATUS Newberry and Worthen.

Plate XLI, Fig. 34.

Deltodus spatulatus Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 100, pl. 4, fig. 7; 1870, Ibid., Vol. 4, pl. 3, fig. 11.

Cochliodus costatus (pars) Newberry and Worthen, 1870, Ibid., p. 364, pl. 3, fig. 12 (not fig. 10).

Deltodus spatulatus Newberry, 1879, Annual Report of the Geological Survey of Indiana, p. 346.

Deltodopsis? convolutus St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 165, pl. 11, figs. 11 and 12.

Cochliodus costaus (pars) St. John and Worthen, Ibid., p. 167.

Deltodus latior St. John and Worthen, Ibid., p. 145, pl. 9, figs. 11 and 12.

Deltodus spatulatus Newberry, 1897, Transactions of the New York Academy of Science, Vol. 16, p. 292, pl. 19, figs. 8-11.

Deltodus spatulatus Eastman, 1903, Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. 39, pl. 4, figs. 41 and 42, pl. 5, fig. 55.

Deltodus spatulatus Branson, 1905, Journal of Geology, Vol. 13, p. 31, pl. 1, figs. 10, 12 and 13.

Posterior teeth triangular in outline, strongly arched longitudinally and transversely. A broad, rounded ridge extends from the outer end to the middle of the inner end; inner end broadly rounded; alation of posterior-lateral border narrow, only slightly upturned, antero-lateral border thick, slightly concave, modified for articulation with anterior teeth.

Formation and Locality.—Keokuk, Harrison County, Indiana; Salem limestone, Salem and Lanesville, Indiana; Kinderhook and Burlington, Iowa and Illinois.

This species has not heretofore been reported from above the Keokuk.

DELTODUS TRILOBUS St. John and Worthen.

Plate XLI, Figs. 27-28.

Deltodus trilobus St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 148, pl. 9, fig. 8.

Median tooth of medium size, wedge-shaped in outline, moderately arched and rather strongly inrolled. Posterior-lateral or oblique border converging toward the outer extremity at an angle of about 15 degrees with the opposite border. Basal portion of moderate depth, rather deeply and angularly channeled. Antero-lateral border proportionately short, the round anterior coronal ridge imbeveled to the relatively shallow, channeled, imbeveled basal rim. Inner margin obliquely produced backward from the obtuse anterior angle to the broadly rounded base of the principal

coronal ridge. The principal ridge occupies half or more of the transverse diameter of the coronal region, rising into a high rounded crest, the anterior slope steep and terminating in a narrow depression outwardly defined by the low narrow anterior ridge along the antero-lateral border. Worn coronal surfaces exhibiting fine closely arranged punctae.

One specimen studied by the writer is about 15 mm. across inner end and more than 30 mm. along the antero-lateral margin.

Formation and Locality.—Salem limestone, Spergen Hill, Indiana, and Jersey County, Illinois.

DELTODUS CINCTUS Newberry.

Plate XLII, Fig. 41.

Deltodus cinctus Newberry, 1879, Geological Survey of Indiana, p. 344.

Deltodus parvus St. John and Worthen, 1883, Paleontology of Illinois, Vol. 3, p. 131, pl. 9, figs. 1-5.

Tooth of medium size, spatulate in outline; much arched in both directions, thick and strong; greatest breadth 25 mm., length 55 mm., upper surface marked transversely by a series of shallow sulci, which curve downward and terminate in the lateral margins, causing these to be slightly crenulated. In the middle portion of the crown these furrows are about 5 millimeters apart; near the lower margin they more closely approximate, and are somewhat irregular; surface uniformly enameled, and rather closely punctate.

It is the writer's opinion that *Deltodus parvus* St. John and Worthen is synonymous with *Deltodus cinctus*. The teeth described by St. John and Worthen are smaller than those of *D. cinctus*, but in other respects agree with them.

As *Deltodus cinctus* has never been figured it is fortunate that the specimen figured here was identified by Professor Newberry himself. The specimen is from the collection of Walker Museum, University of Chicago.

Formation and Locality.—Salem limestone, Greencastle and Harrison County, Indiana; St. Louis group, Pella, Iowa, and St. Louis, Missouri.

DELTODUS sp. indet.

Plate XLI, Fig. 24.

A fragment of a tooth from Lanesville is referred with some doubt to this genus. It differs from *Deltodopsis sanctiludovici* in the area between the postero-lateral border and the median ridge being plane, and the area in front of the ridge being concave.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

DELTODOPSIS? BIALVEATUS St. John and Worthen.

Plate XLI, Figs. 8-9.

Deltodopsis? bialveatus St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 169, pl. 11, figs. 15-18, includes varieties *keokuk* and *convexus.*

In the collection of G. K. Greene there is one imperfect tooth that probably belongs with the group of teeth described by St. John and Worthen as *Deltodopsis bialveatus.* The crown shows a shallow depressed area in the middle near the inner end and the root is narrower than the crown. Lines of growth are deeply impressed.

It seems probable that this is a median tooth of some species of Deltodus.

Formation and Locality.—Salem limestone, Lanesville, Indiana; Burlington and Keokuk limestones, Iowa.

ORODUS NEGLECTUS? St. John and Worthen.

Plate XLII, Figs. 35, 36.

Orodus neglectus St. John and Worthen, 1875, Paleontology of Illinois, Vol. 6, p. 308, pl. 6, fig. 26.

A fragment from Lanesville consisting of the median part of a medium-size tooth is referred to this species with some doubt.

The median cone is unornamented save for a few denticles along the posterior edge of the base and a tuberosity on the anterior edge of the base.

Formation and Locality.—Salem limestone, Lanesville, Indiana; St. Louis group, Illinois and Iowa.

ORODUS SIMPLEX sp. nov.

Plate XLII, Figs. 25, 26.

Type a little more than half of a well preserved tooth. Tooth of medium size, fragment preserved having the central cone and three lateral cones on one side, central cone about twice as large as first lateral cone, second and third lateral cones smaller than first. Central cone ornamented with four low, rounded vertical ridges that disappear before reaching the apex, lateral cones with little or no ornamentation.

Formation and Locality.—Salem limestone, Edwardsville, Indiana.

DESMIODUS SALEMENSIS sp. nov.

Plate XLII, Figs. 12-14.

Tooth large, 12 mm. broad by 10 mm. high. Crown subtriangular in outline, inferior angles slightly rounded, apex appearing truncated on account of the curving downward and outward of the tip. Lateral cutting edges slightly wavy in outline, but with little or no denticulation. The lower border of the crown on the outer or concave surface of the tooth curves upward, running nearly parallel to the cutting edges. The lower margin of the crown is nearly straight on the convex face. Between the margin and the cutting edge the surface of the crown is concave transversely on both the concave and convex surfaces. From the transverse concavity on the convex surface a narrow concavity passes vertically to the tip of the tooth. The coronal surfaces are polished and smooth in the lower portion, but near the crest are marked by shallow narrow furrows, which are almost vertical and parallel at the cutting edge, but turn inward lower down, branch and cross one another, forming small hexagonal figures.

Tooth much constricted at junction of crown with root, root nearly as broad as crown, abruptly thickened near the lower edge, convex surface with deep short vertical furrows and narrow ridges.

This species resembles *D. costelliferous* St. John and Worthen, but differs from it in being more than four times as large, in the shape of the crown and in the comparatively greater breadth of the root.

Formation and Locality.—Salem limestone, Paynter's Hill, Indiana.

CTENACANTHUS PELLENSIS? St. John and Worthen.

Plate XLI, Fig. 25.

Ctenacanthus pellensis? St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 237, pl. 21, fig. 2.

This species is represented by fragmentary material from Salem in the collection of the University of Chicago. It was described from fragments; but the present specimens furnish no new facts about the species.

Spine thick, gradually tapering, obtuse wedge-shaped in cross section, the posterior side deeply excavated by the open trough of the pulp cavity. Lateral surfaces gently convex, somewhat sharply arched into the rounded or subangular anterior edge. Surface ornamentation consisting of numerous delicate longitudinal costae more or less regularly diminished in size from the anterior edge, more frequently bifurcated and deflected on nearing the postero-lateral angles; where they cease at the anterior beveled edge. In front the costae present plain, rounded, enameled crests spaced by narrow intervening sulci, their lateral edges studded with delicate downward curved transverse carinae or tubercles; the third rib from the dorsal edge shows more or less distinct undulations and the fifth rib is surrounded by small steltate tubercles more or less variable in the details of surface sculpture and disposition, their apices directed upward.

Formation and Locality.—Salem limestone, Salem, Indiana; St. Louis group, Pella, Iowa.

CTENACANTHUS BELLUS sp. nov.

Plate XLII, Figs. 19-21.

Types two fragments from near the middle of a medium-sized spine. The spine resembles that of *Ctenacanthus keokuk,* but differs from that form in the greater length of the nodes, in only the three or four anterior costae bearing nodes, in the slenderness of the costae, and the small size and approximation of the posterior costae. Some of the small costae several rows back of the edge bear incipient approximated enlargements, but most of them are smooth. The anterior edge is very thin and bears small tubercles, space between tubercles about twice the width of the tubercles. Along the postero-lateral angles there is a row of moderately

strong tubercles that project outward at right angles to the lateral face of the spine. Pulp cavity small, subtriangular. The nodes on this spine are longer than in *C. longi-nodsus* Eastman.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

gen. et. sp. indet.

Plate XLII, Figs. 30-31.

Among the specimens from Lanesville, there is a peculiar little tooth the relations of which have not been determined. Tooth not quite twice as long as broad, one end much broader than the other, nearly straight and slightly oblique, narrower end rounded. Crown surface low, marked by several imbricating ridges. Ridges quite strong over most of the surface, weak in a narrow strip along one edge. Root cartilaginous.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

JAW OF COCHLIODONT.

Plate XLII, Fig. 37.

In the collection of Walker Museum there is one specimen consisting of a nearly complete right ramous of a mandible of an Elasmobrach. It seems to belong to a large Cochilodont, probably *Cochliodus* or *Deltodus,* but the writer has not been able to find any teeth that fit it in the collections that he has studied. The dentition of the right ramus seems to have consisted of three teeth, a large posterior, smaller median and small anterior tooth.

Formation and Locality.—Salem limestone, Salem, Indiana.

Besides the species described in this paper the following have been reported from the Salem limestone of Indiana: *Antliodus aruatus* Newberry and Worthen, *Antliodus minutus* Newberry and Worthen, *Archaeobatis gigas* Newberry and Worthen, *Chomatodus angustus* Newberry, *Chomatodus obliquus* Newberry, *Chomatodus pusillus* Newberry and Worthen, *Chomatodus selliformis* Newberry, *Copodus marginatus* Newberry, *Lisgodus affinis* Newberry, *Orodus colletti* Newberry, *Sandalodus minor* Newberry and Worthen, *Thrinacodus bicornis* Newberry, *Polyrhizodus littoni* Newberry and Worthen, *Psammodus glyptus* St. John and Worthen.

EXPLANATION OF PLATES.

PLATE VII.

Page

Endothyra baileyi 1201

1. Section, after Brady. Magnified.

Enallophyllum grabaui 1206

2. Side view of specimen showing point of attachment. Natural size. Paynter's Hill. Indiana University collection.

2a. Diagonal section of a specimen showing the tabulated central part. Enlarged.

2b. Side view of specimen showing surface features. Enlarged.

2c. Calyx of 2b, showing fossula, uniting septa, broken tabulum in the calyx and the cardinal septum.

2d. Cross section of 2a, well below the calyx, showing unusually large tabulated zone and fossula at the left side. Enlarged.

2a-d. Are from Lanesville. Collection of G. K. Greene.

Zaphrentis cassedayi 1203

3. Calyx, after Milne-Edwards and Haime. Enlarged.

3a, 3b. Two side views, after Milne-Edwards and Haime. 3a, enlarged. Spergen Hill.

Zaphrentis compressa.. 1204

4. Lateral view, showing compressed sides of base. After Milne-Edwards and Haime.

4a. Lateral view, showing the broad side of a rather curved specimen. From Spergen Hill. Indiana University collection.

4b. View of the broad side of a straight specimen from Paynter's Hill. Indiana University collection.

4c. Calyx, after Milne-Edwards and Haime.

4d. Another view of 4b, showing the amount of compression.

Cystelasma rugosum 1210

5. Lateral view of specimen from Paynter's Hill. Natural size.

5a. Calyx of another specimen from same locality.

5b. Calyx of 5. Both specimens in Indiana University collection.

Bordenia zaphrentiformis 1205

6, 6c. Side view of specimen.

6a. Calyx of the same specimen.

6b. Calyx of another individual. All from Spergen Hill. Natural size. Indiana University collection.

Pentremites conoideus perlongus... 1263

7. Lateral view. After Rowley. ×½.

Pentremites conoideus amplus... 1263

8-8c. Views of this variety. From Rowley. ×½.

Plate VII.

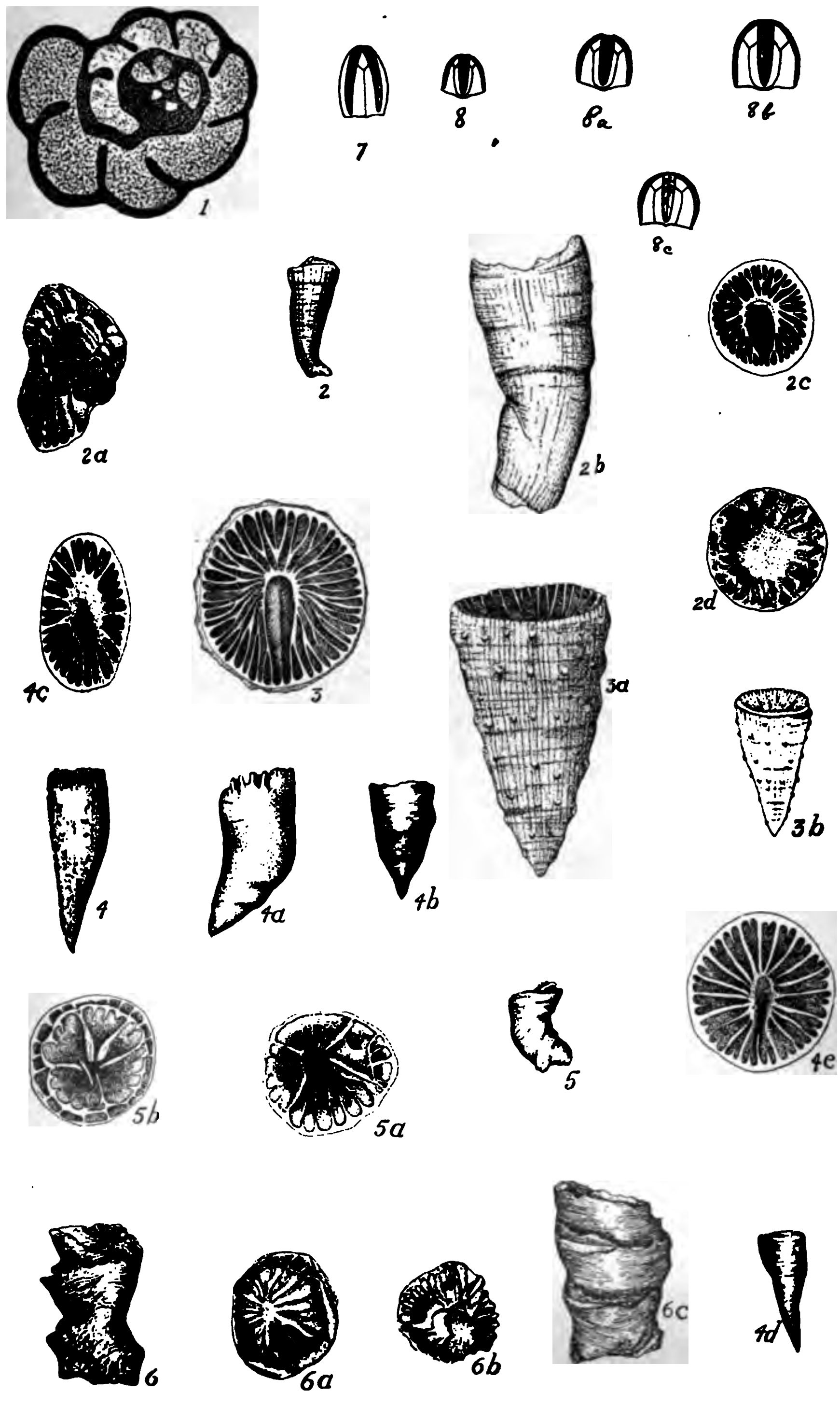


PLATE VIII.

Page

Cystelasma tabulatum 1210

1. Side view of broken type, showing habit of growth.

1a. Nearly same view with outside broken away.

1b. Top view of the same, showing nature of seepta and tabulae.

1c. Calyx of another specimen. Both from Spergen Hill. Enlarged. Indiana University collection.

Cystelasma septatum 1209

2, 2a, 2b. Three side views of a specimen. Natural size. Spergen Hill. Indiana University collection.

2c. Specimen showing a tendency to develop minor septa along one side. Natural size. Lanesville. Collection of G. K. Greene.

2d. Side view of specimen with outer wall removed, showing cysts and the persistence of the primary septa. Enlarged. Spergen Hill, Indiana University collection.

Cystelasma lanesvillensis 1208

3. Lateral view of a specimen, showing one mode of attachment.

3a. Top view of the same specimen.

3b. Young individuals attached to a Bryozoan. Enlarged.

3c, 3d. Lateral view of two specimens, showing the cysts. All natural size. From Lanesville. Collection of G. K. Greene.

Paleacis cuneiformis 1218

4. Side view of specimen. After Meek and Worthen.

4a-c. Side and edge views of three specimens. From Milne-Edwards and Haime. Spergen Hill.

4d-g. Outlines showing variations in form. Specimens from Spergen Hill and Paynter's Hill. Natural size. Indiana University collection.

Amplexus blairi 1202

5. Lateral view, side broken away. Natural size. From Edwardsville. Collection of G. K. Greene.

Plate VIII.

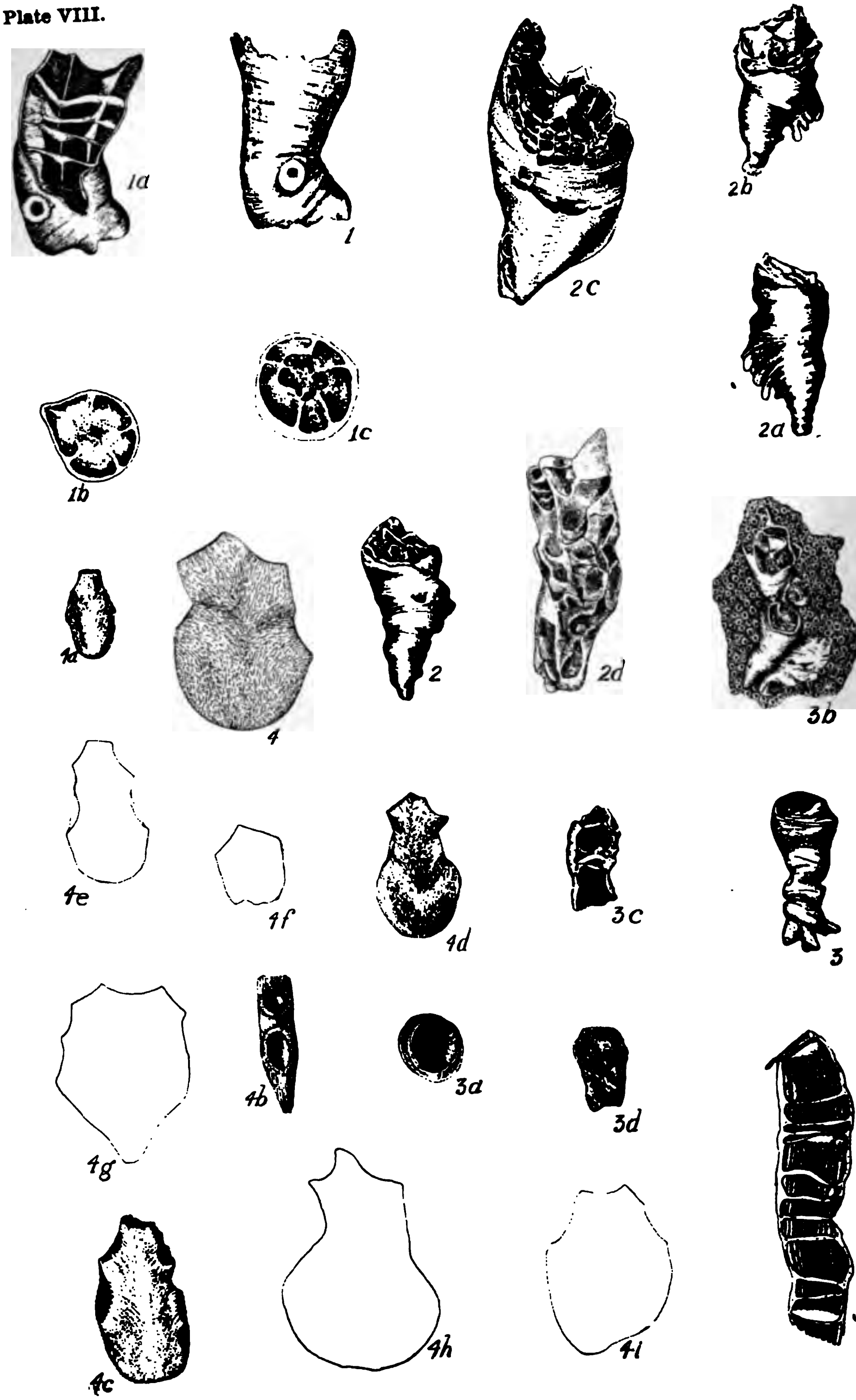


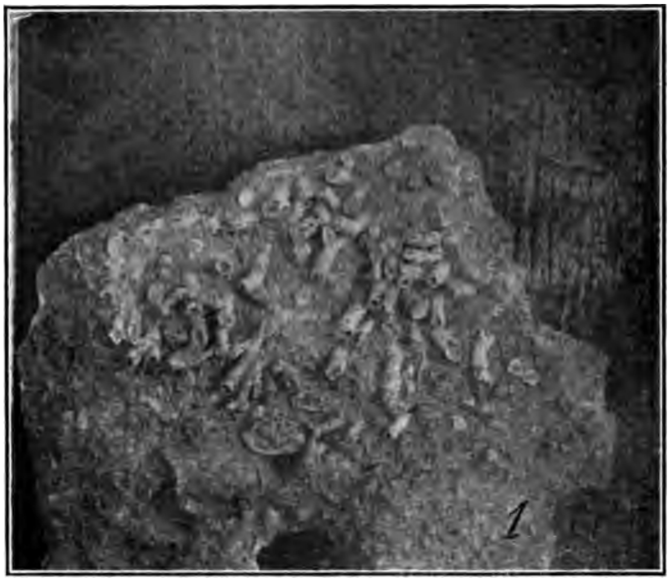
PLATE IX.

	Page
Syringopora monroense	1211

1. A lax young base.

2. Base of another colony which had begun upward growth. Both natural size. From Bloomington quarries. Indiana University collection.

Plate IX.



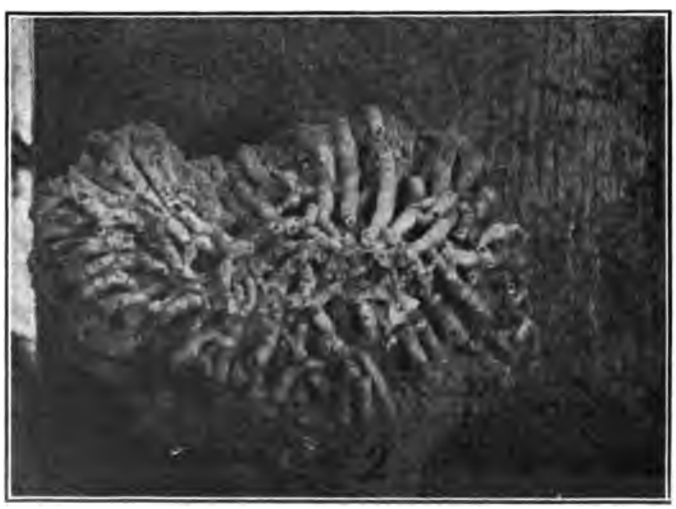


PLATE X.

Page

Syringopora monroense 1211

1. Top view of a specimen, showing umbelliferous habit and the nearly circular openings of the tubes.

2. Side view of type specimen, showing umbelliferous habit, relation of the tubes and manner of budding above the base. Both natural size. From the Bloomington quarries. Indiana University collection.

Plate X.

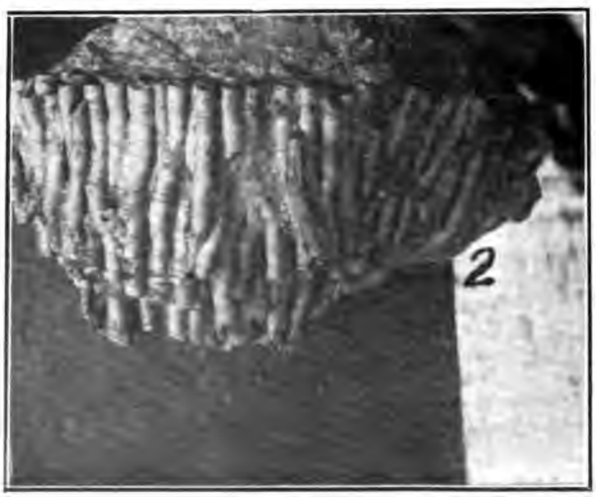


PLATE XI.

Page

Zaphrentis clinatus 1204

1-1c. Sides and calices of two different individuals. After Greene. From Edwardsville. Greene collection.

Cyathaxonia venustum 1202

2. Lateral view of specimen, showing portion of calyx and columella.

2a. View of calyx, somewhat imperfect, of the same specimen. From Paynter's Hill. Indiana University collection.

Cystelasma lanesvillensis 1208

3-3b. Views of three small, slender specimens. Natural size. From Lanesville. Collection of G. K. Greene.

Protopora cystoides 1216

4, 4a. Section and lateral views of two specimens identified by and belonging to G. K. Greene. Natural size. From Lanesville.

4b-d. Three figures redrawn from Greene. Lanesville.

Ceratopora agglomerata 1214

5-5a. Views of specimens redrawn from Cont. Ind. Pal. Lanesville.

Monilopora beecheri 1212

6. View of a specimen from Bedford. Free. *Otronia* tube partly visible on right side a little below the top. Bedford.

6a. Enlargement of the surface of the same to show dttails of markings. From Bedford. Indiana University collection.

Syringopora monroense 1211

7. Single tube of type specimen, showing buds.

7a. Section of the tube of another individual, showing sparse tabulation.

7b. Section of another tube of the same individual, showing crowded tabulae.

7c. Section of crooked tube, showing thickening of the wall of the lower part of the tube. Same specimen as the two previous.

7d. Section of another tube of the same individual, showing a slight tendency to form cysts.

7e. Cross sections of tubes of another colony, showing the thickening of the tubes and parts of concave tabulae cut through. Enlarged.

7f. A bunch of tubes on the type specimen, showing method of budding sometimes seen above the base. All from Bloomington. Indiana University collection.

Michelinia indianensis 1217

8. Lateral view of type. Natural size.

8a. Enlargement of inner part of tubule, showing mural pores and scale-like tabulae. Enlarged. From Lanesville. Collection of G. K. Greene.

Plate XI.

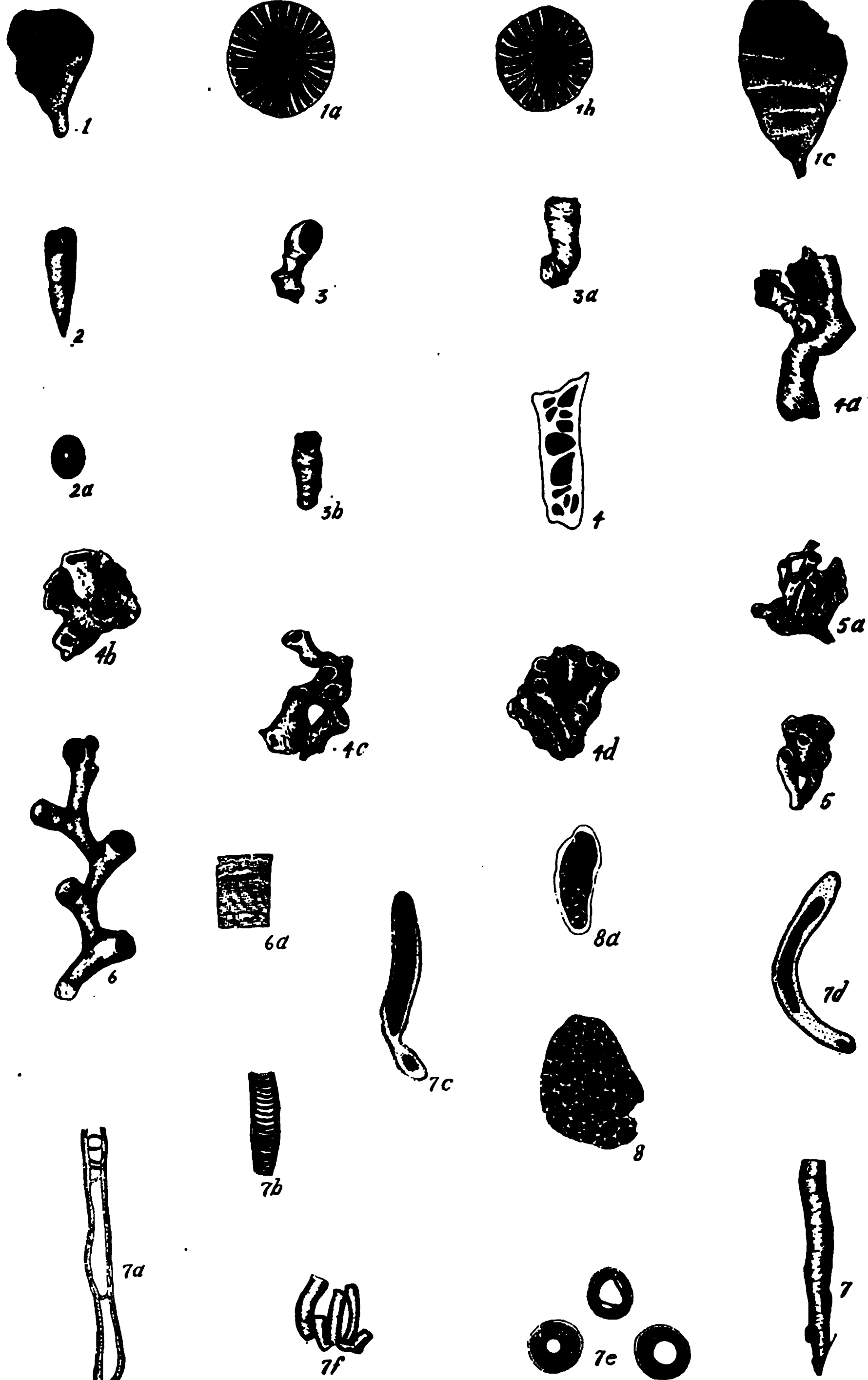


PLATE XII.

Page

Batocrinus irregularis 1244

1. Posterior view, after Wachsmuth and Springer.

1a. Lateral view.

Batocrinus salemensis 1245

2. Basal view, after Miller and Gurley.

2a. Summit view, after Miller and Gurley.

2b. Posterior view, after Miller and Gurley.

Dizygocrinus euconus 1252

3. Showing postero-lateral ray and anal interradials. After Wachsmuth and Springer.

3a. Dorsal aspect of the same specimen.

Dizygocrinus whitei 1252

4. Side view, after Miller.

4a. Basal view, after Miller.

Dizygocrinus decoris 1253

5, 5a. Side and basal views. After Miller.

Batocrinus icosadactylus 1243

6. Lateral view. After Wachsmuth and Springer.

6a. Basal aspect. After Wachsmuth and Springer.

6b. Portion of anal tube. After Wachsmuth and Springer.

Batocrinus sacculus 1246

7-7b. Posterior, basal and top views respectively. After Miller and Gurley.

Batocrinus calyculus 1247

8, 9, 10. Basal parts of calices of crinoids from Spergen Hill.

Plate XII.

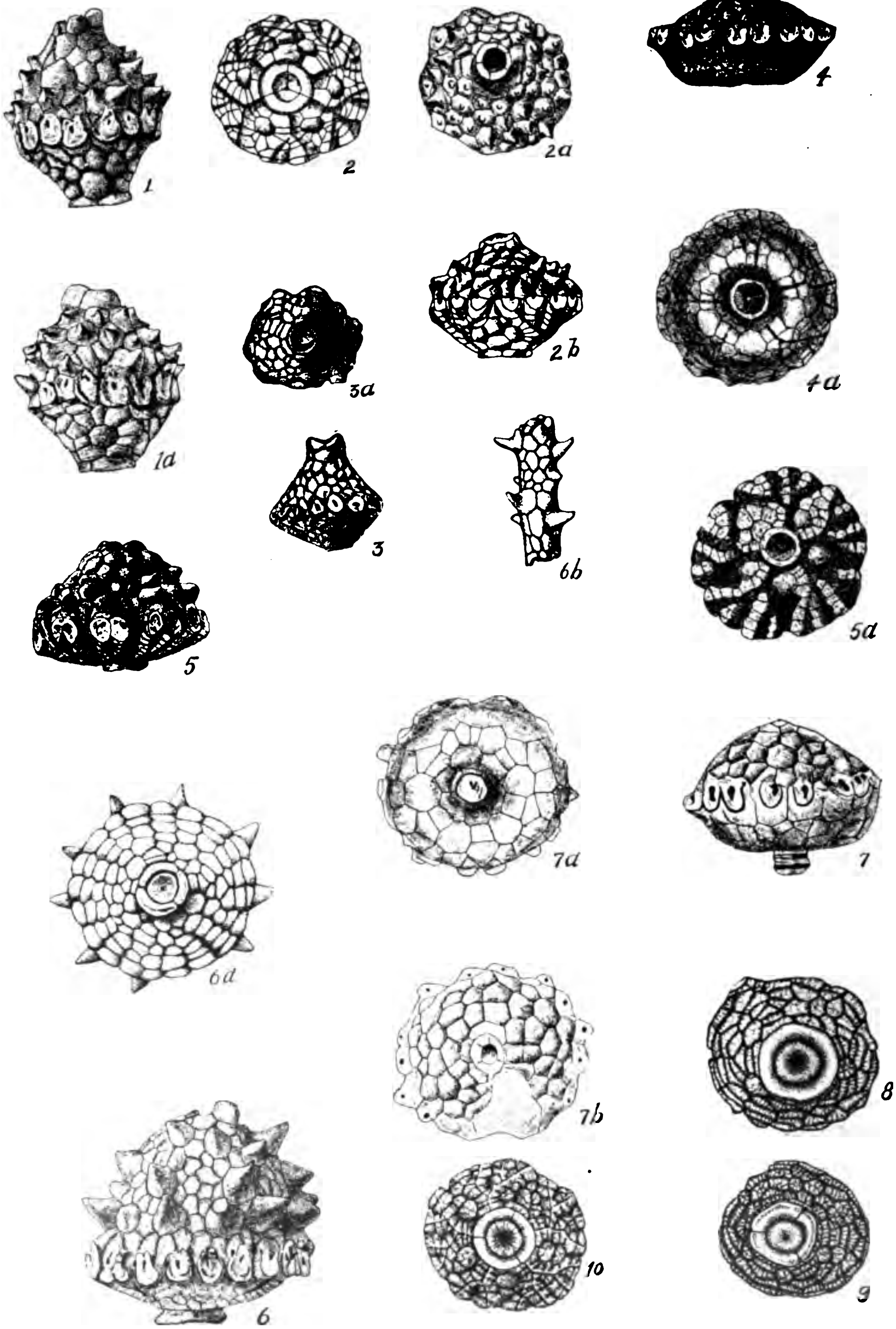


PLATE XIII.

Page

Platycrinus coryphaeus 1256

1. Posterior view. Natural size.

1a. Anterior view, same specimen. Natural size. From Paynter's Hill. Specimen in American Museum.

Platycrinus bonoensis 1255

2. Lateral view of a specimen having six arms to the ray. After Wachsmuth and Springer.

3.

4. Enlargement to show surface detail of Plate XII, Fig. 8.

Dichocrinus striatus 1258

5. Small specimen from Harrodsburg. Enlarged. May be young of this species.

5a. Calyx base of same individual.

5b. Portion of calyx from Paynter's Hill. A somewhat larger specimen.

Forbesiocrinus sp..

6, 6a, 6b. Two parts of calices and the upper part of a stem. Paynter's Hill. American Museum collection.

Talarocrinus simplex 1261

7. Side view.

7a. Base of the same individual × 2-12. From Paynter's Hill.

7b. Side view of a specimen. Natural size. From Bloomington.

7c. Side view of a small specimen from Spergen Hill × 2½. All in the Indiana University collection.

Talarocrinus Cf. trijugus 1260

8. Specimen from Paynter's Hill. Enlarged. Indiana University Collection.

Dichocrinus oblongus 1260

9. Posterior view. After Wachsmuth and Springer.

Forbesiocrinus sp..

10. Looking down on top of the column. From Paynter's Hill. Indiana University collection.

Synbathocrinus swallowi 1262

11. Basal view of calyx of a specimen from Paynter's Hill. Indiana University collection.

Plate XIII.

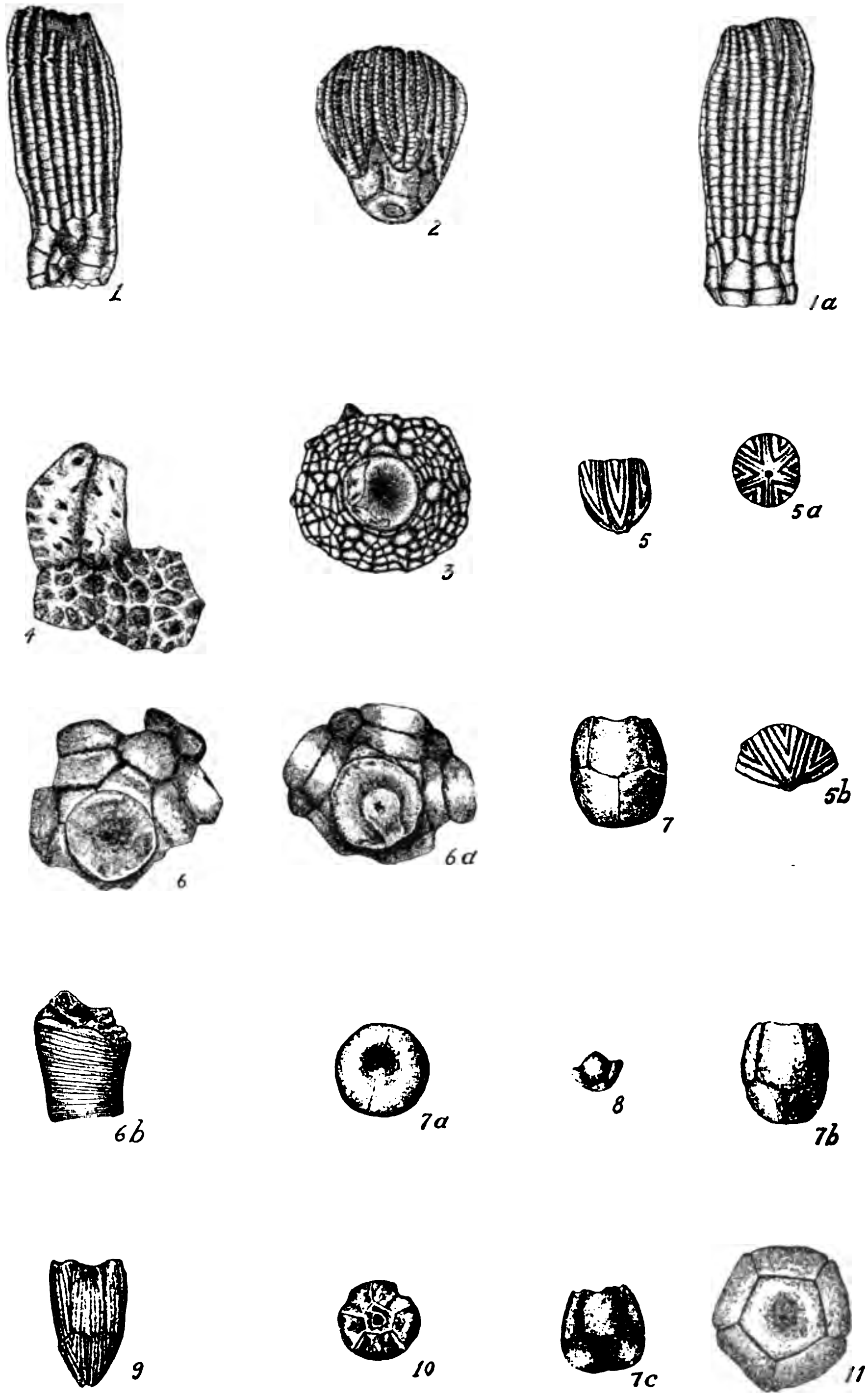


PLATE XIV.

Page

Synbathocrinus swallowi 1262

1. Top view of calyx of specimen figured. Plate XIII, Fig. 11.

Tolarocrinus Cf. trijugus 1260

2. Basal view of calyx.

2a. Top view of calyx of the same specimen. Enlarged. From Lonesville. Collection of G. K. Greene.

Batocrinus calyculus 1247

3, 3a. Posterior and anterior diagrams of calyx. After Hall.

3b. Diagram of plates. After Hall.

Icthyocrinus clarkensis 1257

4. Lateral view of specimen.

Platycrinus boonvillensis 1256

5, 5a. Two lateral views, one showing base.

5b. Base of another specimen. All taken from Wachsmuth and Springer's illustrations.

Archaeocidaris norwoodi 1268

6. Side view of a very small plate highly magnified, showing striae.

6a. Top view of same very highly magnified, showing striae. From Spergen Hill. Indiana University collection.

Tricoelocrinus meekianus 1266

7. Base of specimen from Bedford.

7a. Base of another specimen from Bedford. Note the nearly flat base with depressions.

7b. Top aspect of No. 7 somewhat crushed.

7c. Enlargement of a portion of the surface of No. 7 to show the markings.

Troostocrinus wortheni 1266

8. Lateral view of specimen, young, after Shumard. Much enlarged.

8a. Enlargement of Ambulacral area, as figured by Shumard.

8c. Enlargement of the summit according to Shumard.

Synbathocrinus swallowi 1262

9. Top view of calyx, showing posterior notch and the prong on the edge of the rarial on the right. From Lanesville. Natural size. Indiana University collection.

Plate XIV.

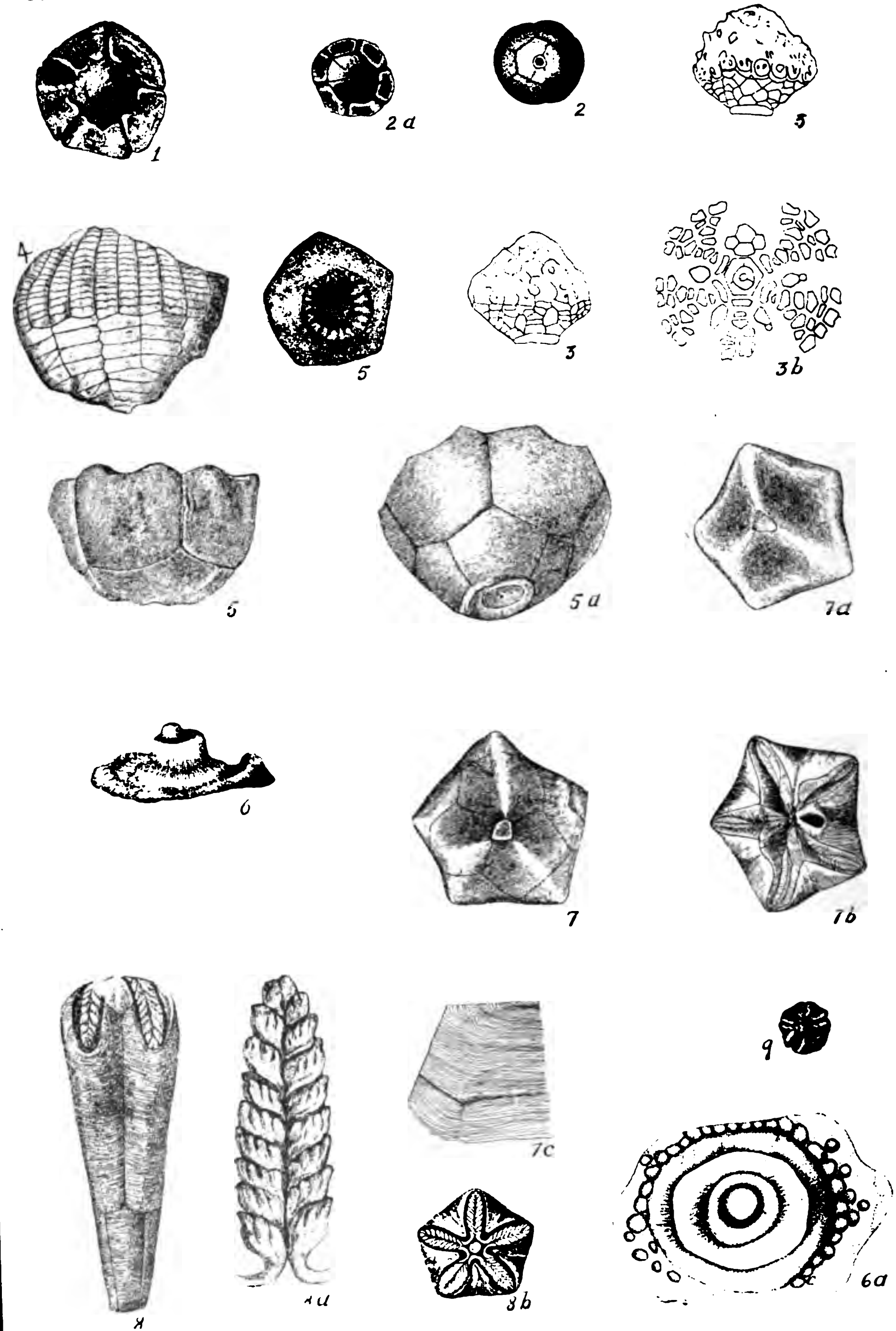


PLATE XIV.

Page

Synbathocrinus swallowi 1262

1. Top view of calyx of specimen figured. Plate XIII, Fig. 11.

Talarocrinus Cf. trijugus 1260

2. Basal view of calyx.

2a. Top view of calyx of the same specimen. Enlarged. From Lonesville. Collection of G. K. Greene.

Batocrinus calyculus 1247

3, 3a. Posterior and anterior diagrams of calyx. After Hall.

3b. Diagram of plates. After Hall.

Icthyocrinus clarkensis 1257

4. Lateral view of specimen.

Platycrinus boonvillensis 1256

5, 5a. Two lateral views, one showing base.

5b. Base of another specimen. All taken from Wachsmuth and Springer's illustrations.

Archacocidaris norwoodi 1268

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8c. Enlargement of the summit according to Shumard.

Synbathocrinus swallowi 1262

9. Top view of calyx, showing posterior notch and the prong on the edge of the rarial on the right. From Lanesville. Natural size. Indiana University collection.

Plate XIV.

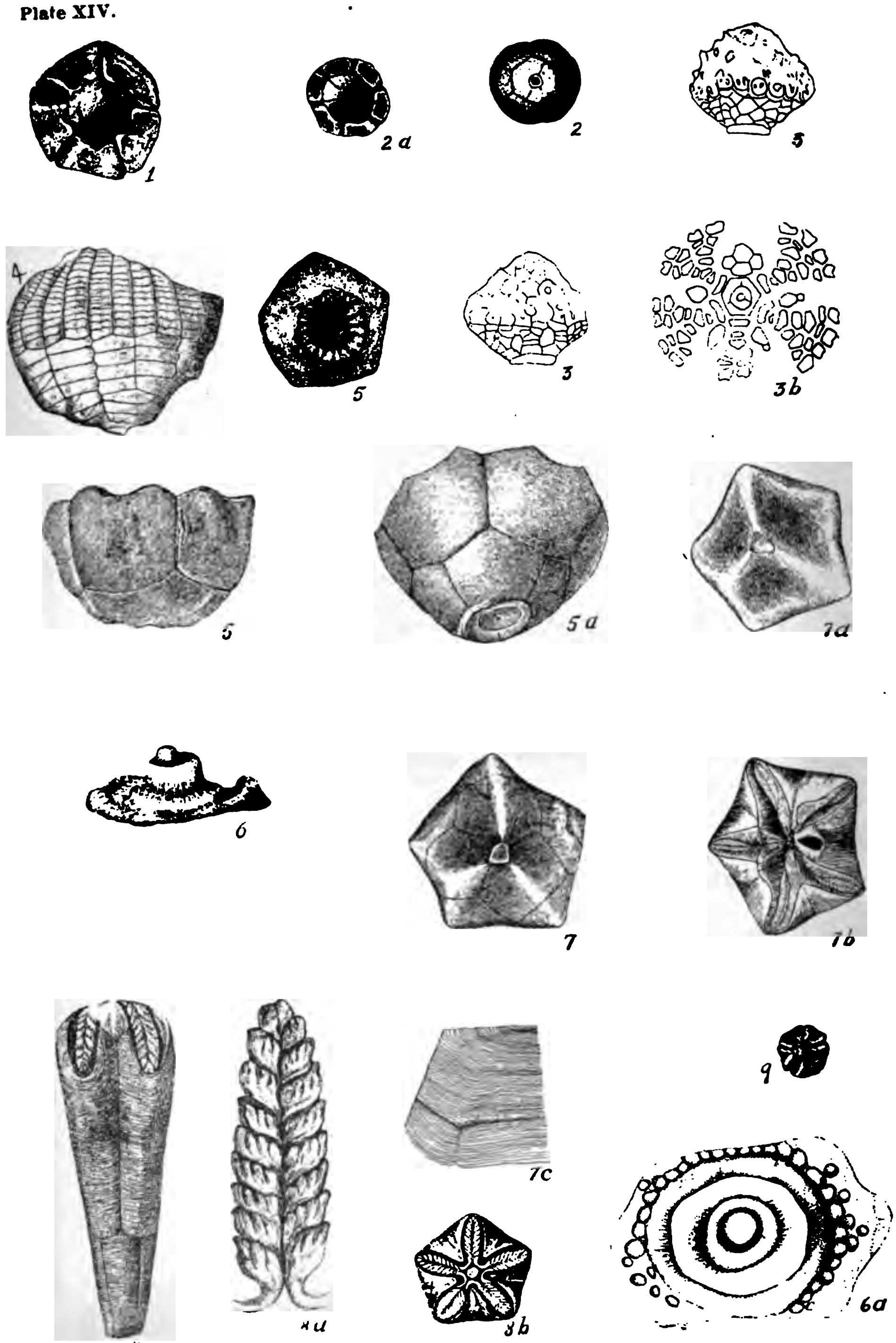

PLATE XV.

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Batocrinus magnirostris 1244

1, 2, 3. Ventral, side and dorsal views of the type specimen.

Batocrinus irregularis 1244

4, 5, 6. Ventral, anal side and dorsal views of a small specimen.

Batocrinus davisi 1248

7, 8, 9. Ventral, anal side and dorsal views of a sptcimen.

Batocrinus crassitestus 1249

10, 11, 12. Ventral, side and dorsal views of the type specimen.

Batocrinus davisi 1250

13, 14, 15. Ventral, anal side and dorsal views of the type.

Batocrinus icosidactylus 1243

16, 17, 18. Ventral, anal side and dorsal views of a fine specimen.

Batocrinus icosidactylus 1243

19, 20, 21. Ventral, side and dorsal views of a small specimen with a portion of the ventral tube attached.

24, 25. Views of two detached ventral tubes.

26. Side view of a ventral disk with the base of the ventral tube.

27, 28. Basal and side views of the dorsal cup of a large specimen.

Batocrinus davisi sculptus 1250

22, 23. Side and dorsal views of a slightly crushed specimen.

Plate XV.

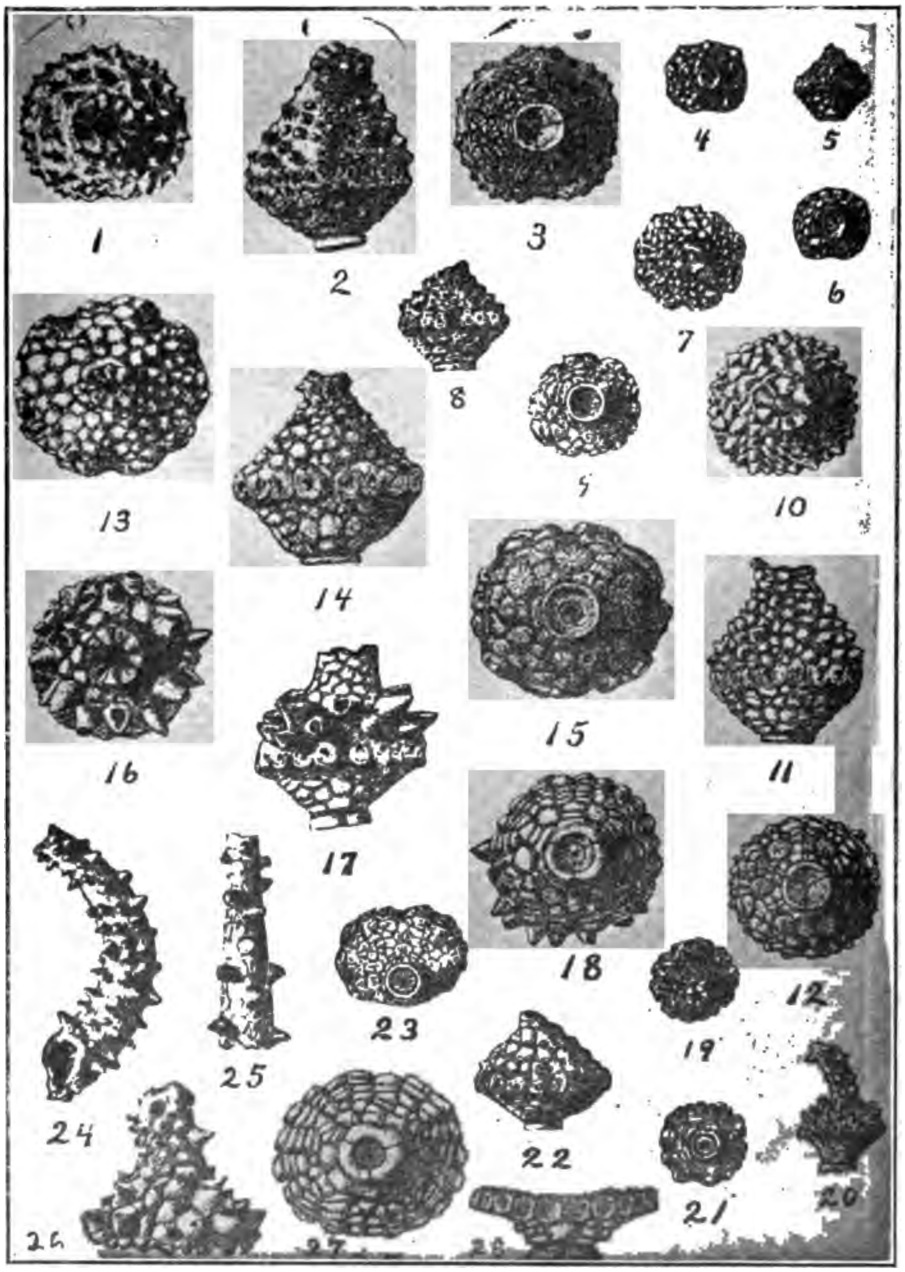

PLATE XVI.

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Dizygocrinus unionensis 1253

1-1d. Views of specimens with and without arms. After Wachsmuth and Springer.

Dizygocrinus euconus 1252

2. View of base.
2a. Lateral view of specimen. After Wachsmuth and Springer.

Temnocheilus coxanus 1370

3. Umbilical view of specimen, after Meek and Worthen.
4. Posterior view of specimen.

Plate XVI.

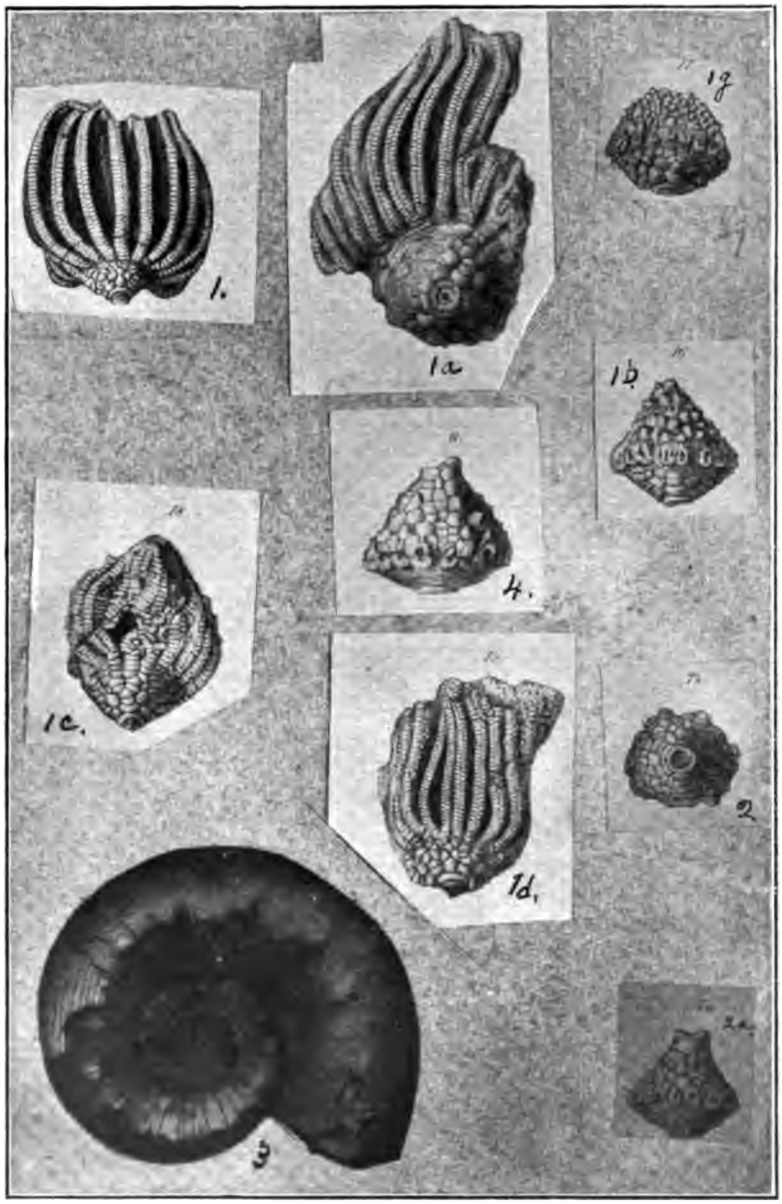

PLATE XVII.

Page

Dichocrinus striatus? 1258

1. Basal view of calyx.

1a. Lateral view of basal plate. Enlarged. Both from Paynter's Hill. Indiana University collection.

Dichocrinus blatchleyi 1259

2, 2d. 2e. Lateral views of parts of bases, showing surface marks.

2a. 2b. 2c. 2f. Radial plates showing markings. All enlarged. From Paynter's Hill. Indiana University collection.

Archaeocridaris norwoodi 1268

3-3e. Smooth spines with only extremely fine lingitudinal lines.

3f-i. Specimens with incipient barbules. All enlarged. From Harrodsburg. Indiana University collection.

Metablastus wortheni 1266

4, 4a. Lateral views of the specimens.

Spirorbis imbricatus 1271

5-5c. Side views of specimens. White ones from Harrodsburg. All enlarged. Indiana University collection.

Spirorbis annulatus 1271

6. A specimen similarly enlarged with the others for comparison. Indiana University collection.

Dizygocrinus sp? 1254

7. Basal view of specimen. Collection of G. K. Greene.

Plate XVII.

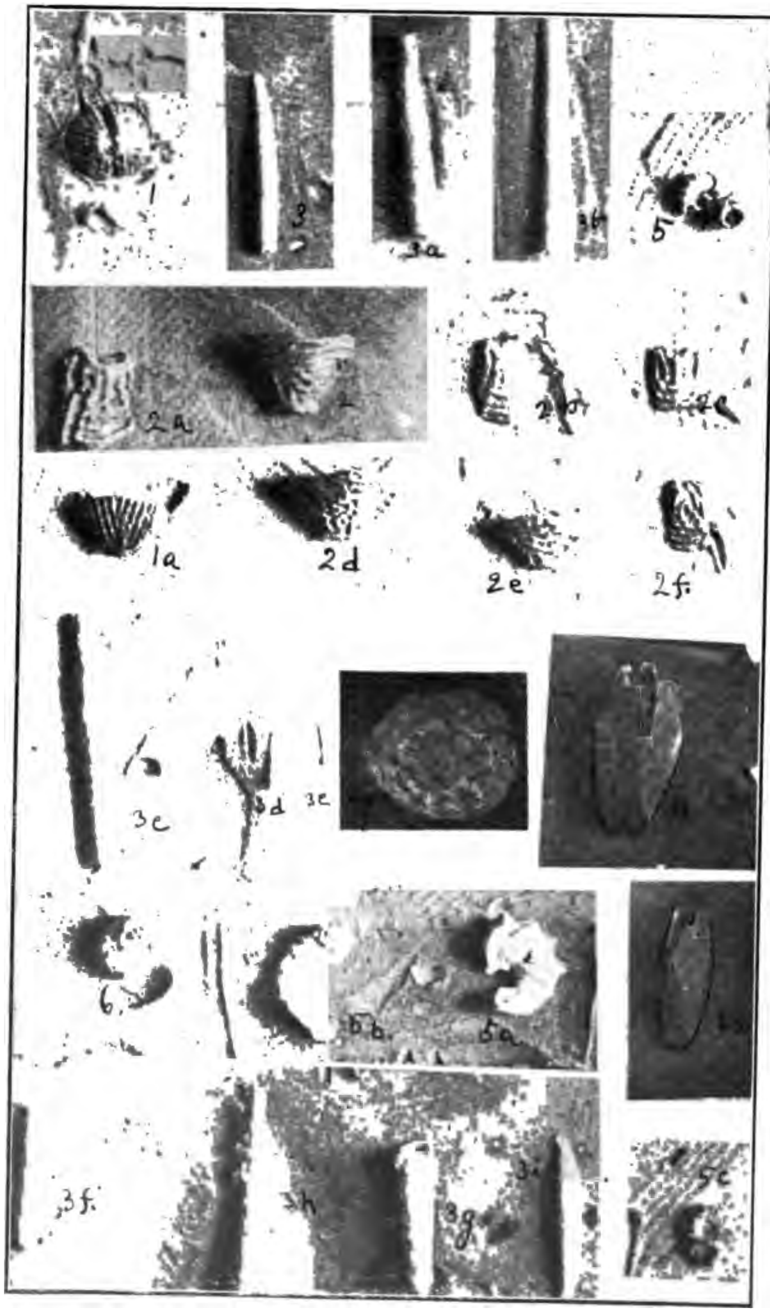

PLATE XVIIA.

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Productus burlingtonensis var. 1301

1, 1a. Lateral and vertical views of two specimens. Natural size.

1b. Posterior view of a specimen with somewhat coarser markings and more produced and inflated beak.

1c. Inside of brachial valve of specimen with internal marks removed. All natural size and from Spergen Hill. Indiana University collection.

Productus gallatinensis 1302

2, 2a. Posterior and vertical views of two specimens. Natural size. From Spergen Hill. Indiana University collection.

3-3e. Views of specimens after Girty, for comparison.

Productus burlingtonensis 1301

4, 4a. Specimens after Hall, for comparison with No. 1.

Archaeocidaris norwoodi? 1268

5-5f. Various views of supposed teeth of this species. Natural size. From Paynter's Hill. Indiana University collection.

Spirorbis imbricatus 1271

6. Specimen from Bedford attached to a Bryozoan. Enlarged. Indiana University collection.

Plate XVIIA.

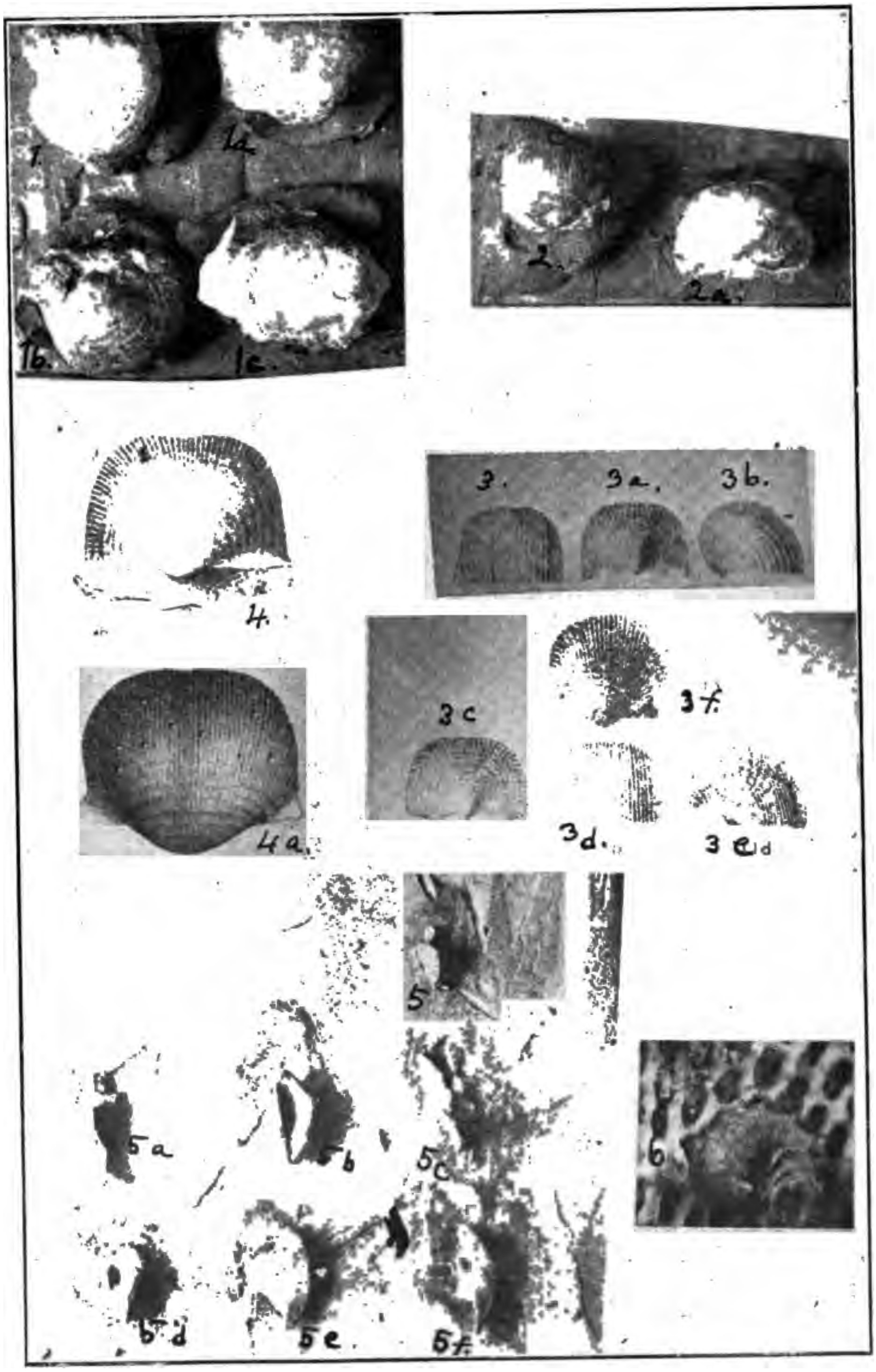

PLATE XVIII.

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Orthothetis minutus 1297

1. Ventral valve of a specimen 4.75 mm. broad.

1a. Dorsal valve of a specimen 5.5 mm. broad by 4 mm. long.

2. Profile view of a specimen 5 mm. long.

3, 4, 5. Ventral, profile and cardinal views of a specimen 0.9 mm. broad and 0.6 mm. long.

6, 7, 8. Three views of a specimen 2 mm. broad which has an abnormally convex ventral valve and an abnormally short area.

9, 10, 11. Three views of a specimen 2 mm. broad.

12, 13, 14. Specimen 2.5 mm. broad.

15 and 16. Ventral and dorsal interiors of two mature specimens.

Plate XVIII.

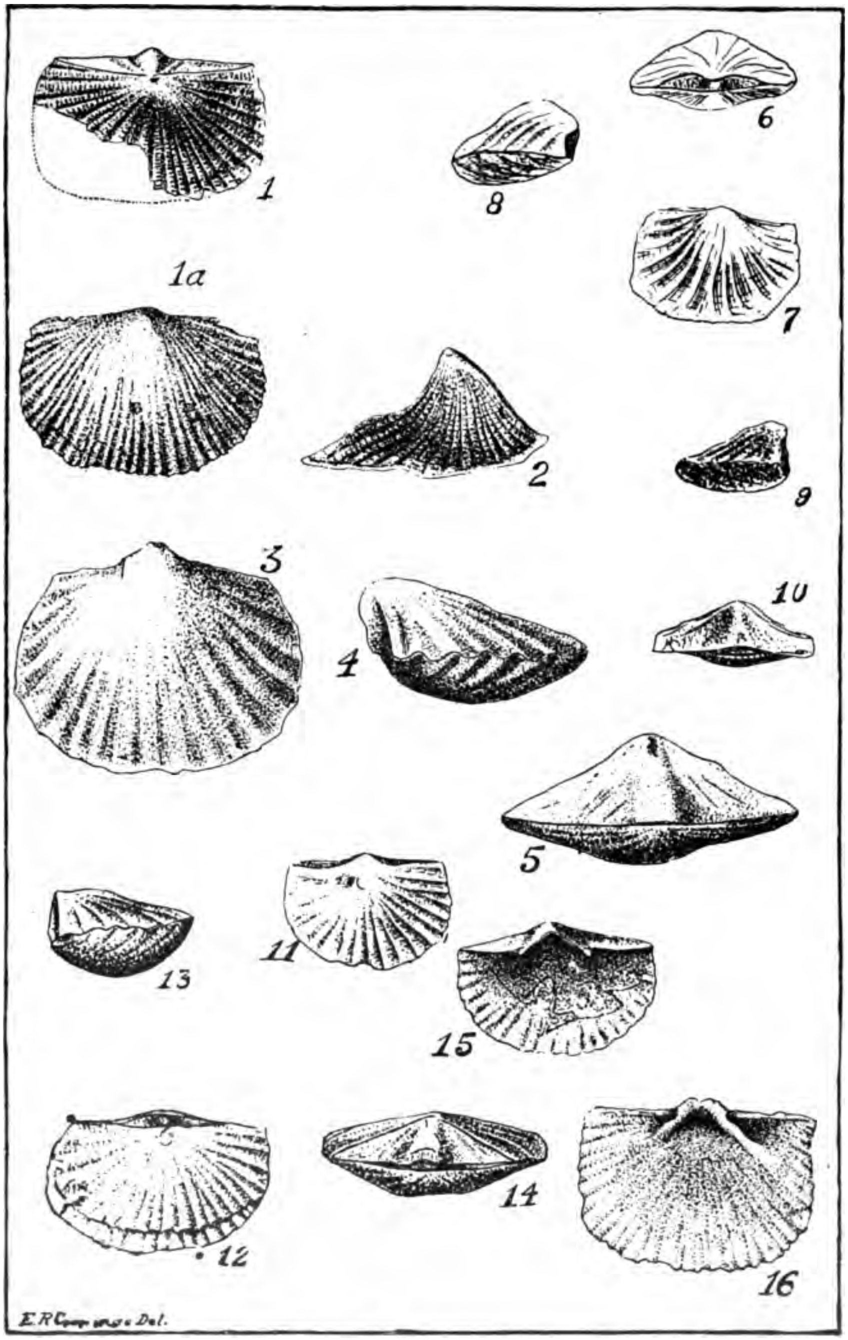

PLATE XIX.

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Cleiothyris hirsuta 1320

1. View of hinge plate from the front, showing the elevation of the plate, crural bases and minute visceral foramen.

1a. View of same from above, showing crescentiform wall made by crural lobes and thick central lobe of the plate. After Hall and Clarke. From Bloomington.

Athyris densa 1320

2. Interior of large pedicle valve, showing the thickening of the shell in the unbonal region and the mesial ridge. From Washington County, Indiana.

2a. Dorsal view of complete specimen.

2b. Interior of pedicle valve, showing further details of muscular impressions. Both from Colesburg, Ky.

2c. Another pedicle valve with septum and dim muscular impressions. From Washington County, Indiana. All after Hall and Clarke.

Spirific suborbicularis 1312

3. Cast of pedicle valve, showing deep impressions of the dental lamellae and traces of muscular impression. Shell badly worn.

3a. Interior of pedicle valve, showing details of muscular impressions and dental lamellae with the teeth, broad foramen and high beak. Natural size. Both from Lanesville. Collection of G. K. Greene.

Pugnax? quadrirostris 1306

4. View of anterior end, showing linguate extension of pedicle valve.

4a. Lateral view of another specimen.

4b. Brachial view of the same specimen. All from the Big Creek quarries. Greatly enlarged. Indiana University collection.

4c. Lateral view of type specimen, showing concave brachial valve and its wing-like shape, and its relation to the pedicle valve.

4d. Brachial view of the same.

4e. View of pedicle valve, showing radiating plications. Very faint. From Harrodsburg. Highly magnified. Indiana University collection.

Dielasma turgidum 1309

5, 5a. Lateral and pedicle views of a gigantic specimen from Lanesville. Natural size. Collection of G. K. Greene.

Productus biseriatus 1299

6. A specimen showing spines in place. From Bloomington. Natural size. Indiana University collection.

Productus Indianensis 1300

7. Brachial views of specimen, showing very concave brachial valve. Natural size. From Lanesville. Collection of G. K. Greene.

7a. Specimen from Bloomington, showing convex interior of valve, cardinal process, muscular marks, mesial ridge and lateral thickening along the hinge. Natural size. Indiana University collection.

Ortonia blatchleyi 1273

8. Two tubes as they lie attached to *Monilopora beecheri*. Types. From Bedford. Indiana University collection.

Holothurian? spicules 1270

9-17. Spicules of various forms highly magnified. Harrodsburg. Indiana University collection.

Plate XIX.

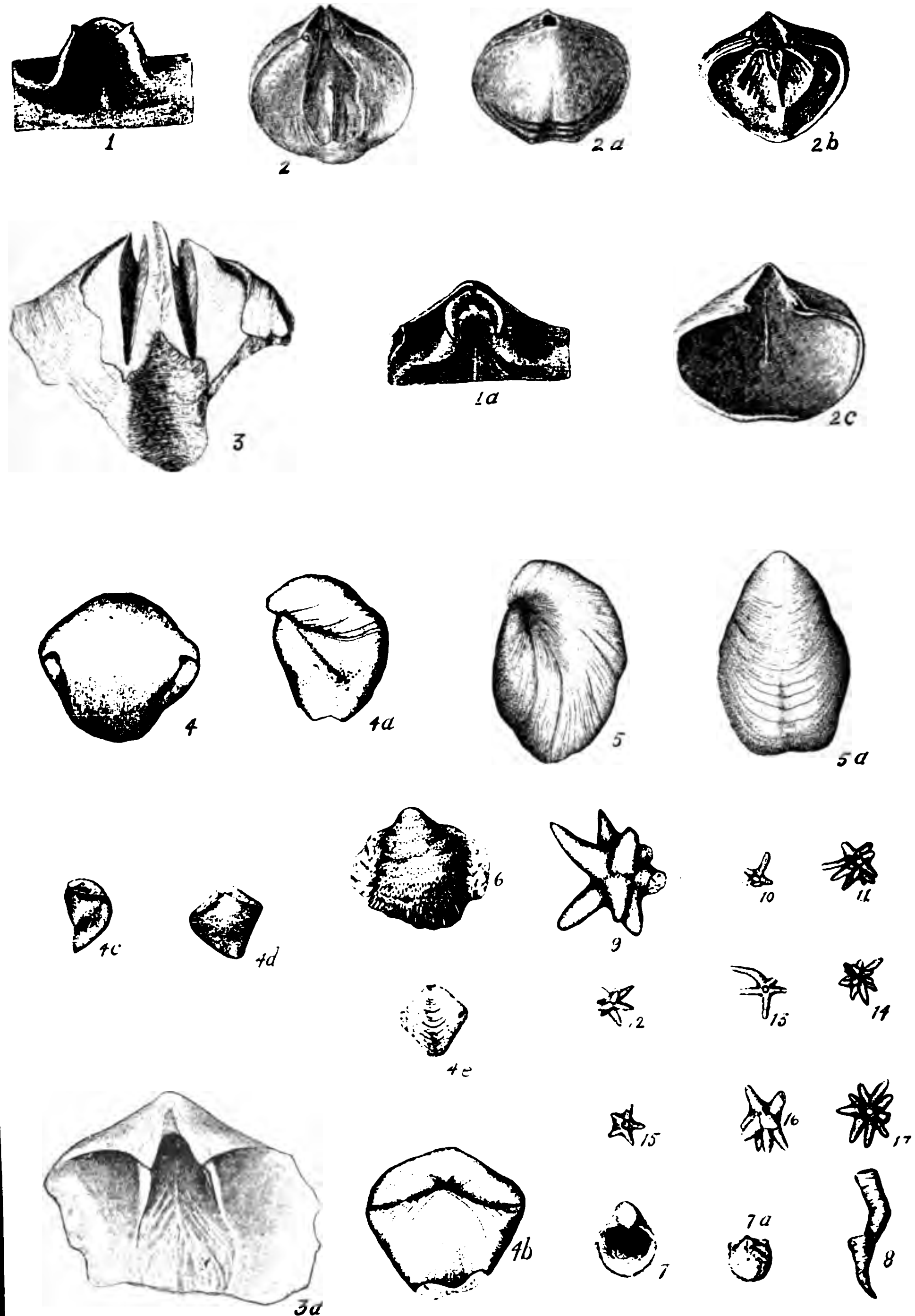

PLATE XX.

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Productus burlingtonensis var. 1301

1. Specimen figured on plate XVIIA, with the produced beak and rather coarse striae.

1a. Brachial valve of another specimen. Both natural size. From Spergen Hill. Indiana University collection.

Spirifer horizontalis 1315

2, 2a. Lateral and brachial views of the type. After Rowley. Lanesville. G. K. Greene collection.

Spirifer lateralis delicatus 1314

3. Cardinal view of specimen. After Rowley.

3a. Anterior view of another specimen. After Rowley.

Spirifer subaequalis 1316

4. Cardinal view of specimen from Lanesville.

4a. View of pedicle valve of the same.

4b. Interior of brachial valve of another specimen from the same locality. All from Lanesville. In the collection of G. K. Greene.

Dielasma gorbyi 1310

5. Pedicle valve. Natural size. From Edwardsville. Collection of G. K. Greene.

Reticularia pseudolineata 1317

6. Interior of pedicle valve, showing septum, dental lamellae, teeth, and wide base of the foramen.

6a. Posterior view of the same, showing hinge line and area, broad foramen. From Bedford. Natural size. Indiana University collection.

Orthothetes minutus 1297

7. A very old, wrinkled pedicle valve with the usual distorted beak. Natural size. Lanesville. Indiana State Museum collection.

Cephalopod . . . .

8. A large portion of the living chamber; × ½. From Elletsville. Indiana State Museum collection.

Plate XX.

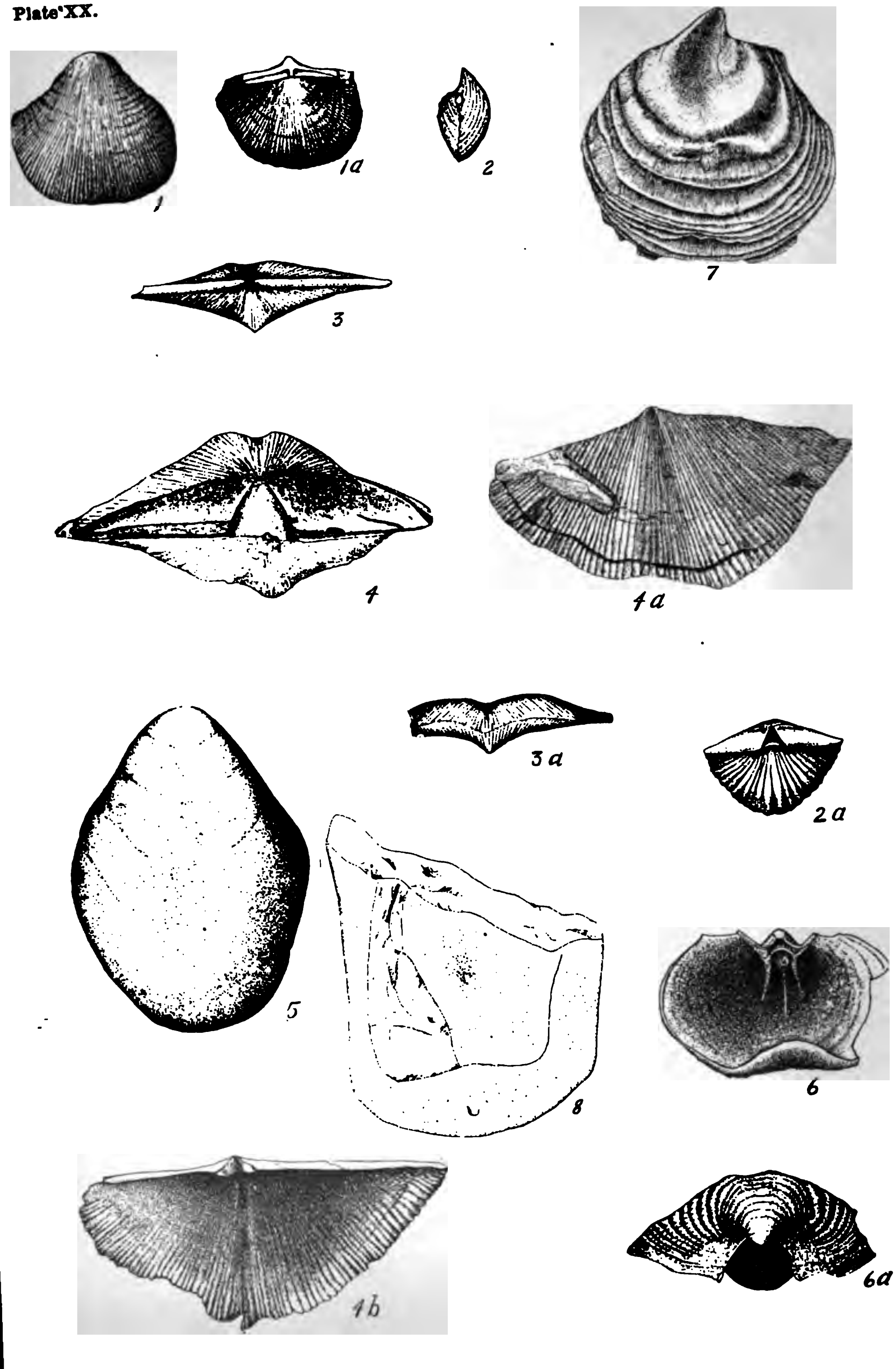

PLATE XXI.

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Reticularia setigerus	1318

1, 1a. Brachial and pedicle aspect of a specimen. After Hall.

Spirifer subcardiiformis	1313

2. Brachial aspect of specimen. After White.

2a. Lateral view of same. After White. From Spergen Hill.

Spirifer subaequalis	1316

3, 3c. Specimens showing pedicle, brachial and cardinal aspects to compare with previous figures of the species. After Hall.

Spirifer subordicularis	1312

4. Lateral view of specimen. After Hall.

Reticularia pseudolineata	1317

5. Specimen fragment, showing the double-barreled spines with barbules: × 2. From Bedford. Indiana University collection.

Plate XXI.

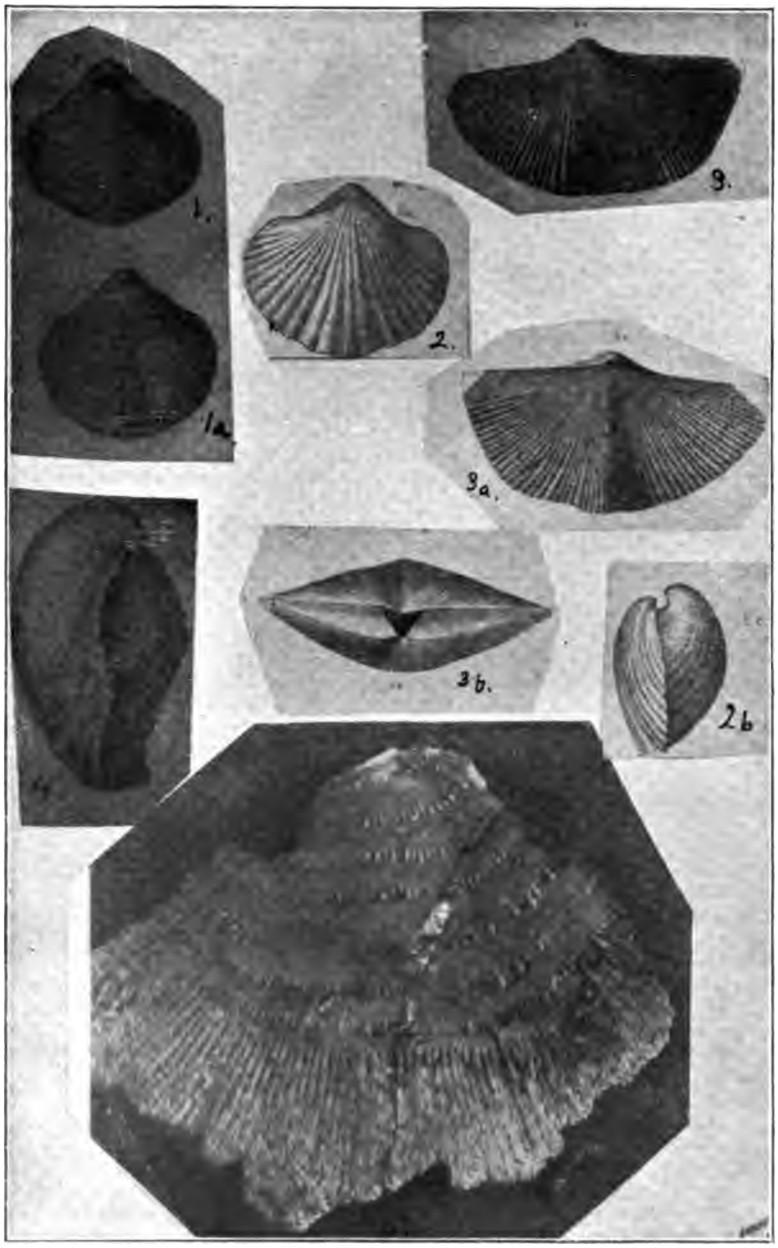

PLATE XXII.

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Rhipidomella dubia 1303

1. Dorsal view of a ventricose specimen from Bloomington, Ind.

2-4. Three views of a larger specimen from Spergen Hill, Ind.

5. Interior of ventral valve of a large individual from Paynter's Hill.

Productus Indianensis 1300

6, 7. Profile and vertical views of [illegible] type specimen (2x).

Productus biseriatus 1299

8. Enlarged (2x) view of interior of dorsal valve. From Bloomington.

9. Another nat. size from Alton, Ill.

10-12. Three views of a large specimen from Spergen Hill. From later collections.

Spirifera bifurcata 1314

13. View of the original specimen (6x).

14. A larger individual (3x).

15. A still larger one (2x) from Spergen Hill.

Spiriferina Norwoodana 1311

16, 17. Dorsal and front views of one of the types (3x). From Alton, Ill.

Cleiothyris hirsuta 1320

18. A small Spergen Hill specimen (2x), showing setæ.

19-21. Three views of a larger specimen from later collections at the same locality.

Seminula trinuclea 1322

22, 23. Views of two specimens from Bloomington, showing variation of form.

24-27. Views of a larger specimen more recently obtained from Spergen Hill.

Eumetria marcyi 1319

28. View of a specimen (2x) from Spergen Hill.

29. From a specimen more recently obtained from Paynter's Hill, Ind.

30. Enlargement of hinge from one of the originals.

Pugnax Grosvenori 1305

31, 32. Views (2x) of a large rotund specimen.

33, 34. A smaller one (3x) from Bloomington, Ind.

Camarophoria Wortheni 1305

35-38. Four views (2x) of the type specimen showing strong plications.

39. One (2x) showing a different form of plication.

Rhynchonella macra 1307

40-42. Three views (2x) of a large specimen from Alton, Ill.

Pugnax mutata 1306

43. Dorsal view of a specimen of medium size.

44, 45. Dorsal and front views of a large one. Alton, Ill.

Rhynchonella recinula 1308

46. Dorsal view (6x) of one of the originals from Spergen Hill.

Camerophoria subcuneata 1304

47-49. Dorsal, ventral and profile views of a specimen from Bloomington, Ind.

Centronella crassicardinalis 1308

50-52. Exterior, interior and profile views of a separated ventral valve of a specimen from Spergen Hill, Ind.

Dielasma turgida 1309

53-55. Three views of a specimen of medium size from Bloomington, Ind.

56-58. Similar views of a larger specimen from Ellettsville, Ind. From later collections.

Dielasma formosa 1310

59, 60. Two views of a small specimen from the original collection.

61-64. Similar views of larger specimens subsequently obtained. Spergen Hill.

Plate XXII.

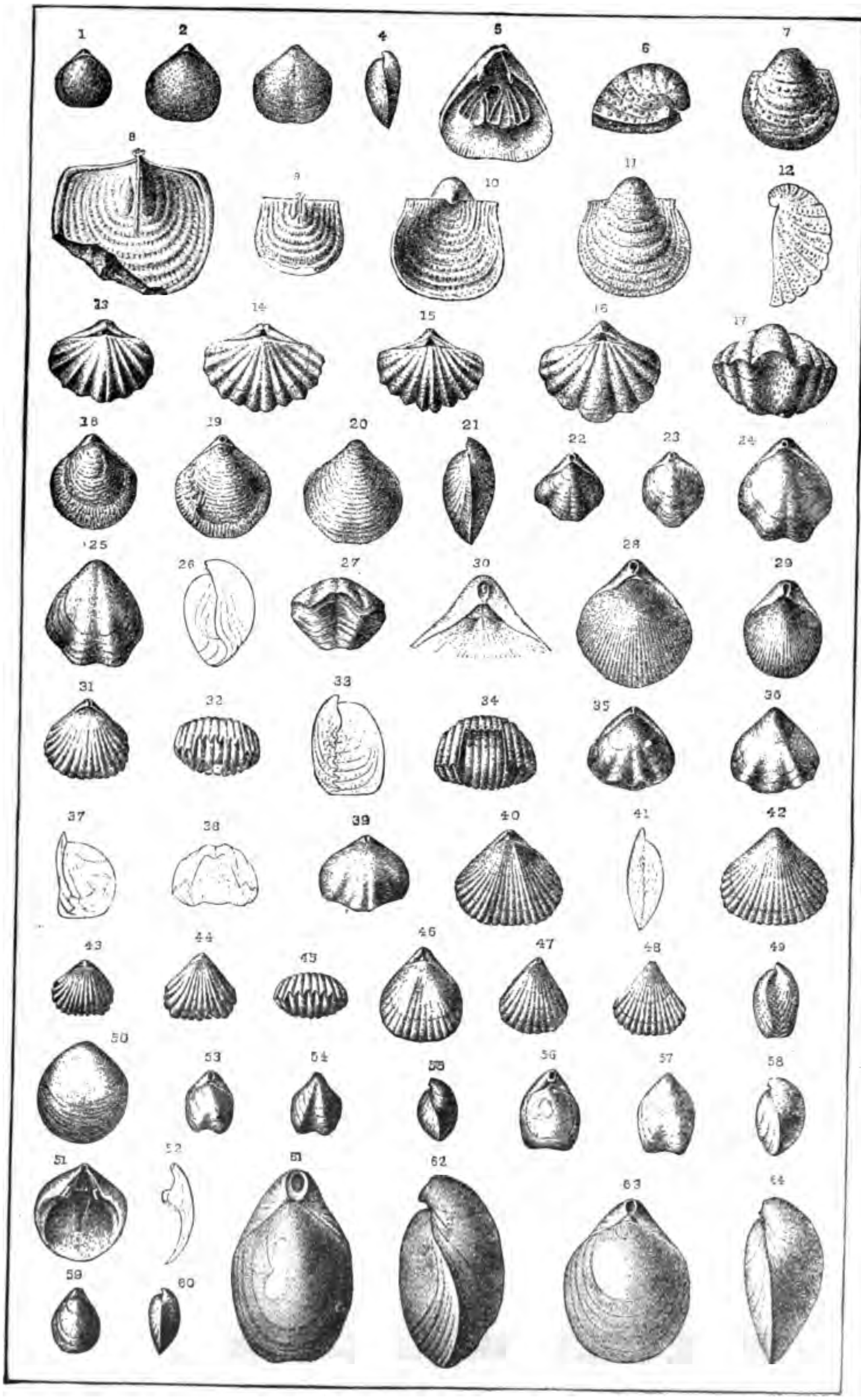
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PLATE XXIII.

Page

Pteronites Spergenensis 1323

1. View of a left valve of the species (2x) from Spergen Hill.

Nucula Shumardana 1323

2, 3. Lateral and cardinal views (2x) of a specimen of normal form.

4, 5. Lateral and dorsal views of a more elongate specimen (2x) from later collections.

6. Outline view, showing hinge (3x).

Nuculana nasuta 1324

7, 8. Similar views (4x) of two original specimens.

9. View (3x) of a specimen subsequently obtained. All Spergen Hill, Ind.

Cypricardinia Indianensis 1324

10. Cardinal view (4x) of a specimen from a later collection, showing both valves.

11. End view, showing the inequality of the valves.

12. View of the hinge (3x) as shown on a specimen from later collections from Spergen Hill.

13, 14. Cardinal and lateral views (2x) of original specimens from Bloomington, Ind.

Conocardium catastomum 1325

15-17. Lateral views of specimens from Spergen Hill (4 and 3x).

16. Basal view of the specimen 15.

Conocardium carinatum 1326

18, 19. Posterior and lateral views (2x) of an imperfect specimen. Spergen Hill.

Conocardium pcattenanum 1328

20. Enlarged lateral view (4x) of the only example of the species obtained. Alton, Ill.

Conocardium Meckanum 1328

21-23. Three views (3x) of a specimen from Alton, Ill.

Conocardium cuneatum 1327

24, 25. Lateral and posterior views (2x) of a specimen from Bloomington.

26. Basal view (2x) of one from Spergen Hill, Ind.

Microdon subellipticus 1330

27, 29. Lateral and cardinal views (3) of a specimen from Spergen Hill.

28. View (3x) of another specimen, showing hinge.

Microdon oblongus 1330

30, 31. Lateral and cardinal views (2x) of the principal type specimen. This specimen was given in the Iowa Geol. Rept. as *C. nucleata*.

32. View (2x) of a cast showing muscular imprints.

33. Enlargement of the hinge from a separated valve subsequently collected.

34. View of a very large valve (natural size) subsequently collected. Spergen Hill, Ind.

Microdon nucleatus 1331

35, 36. Lateral and cardinal views of a specimen (4x) from Spergen Hill.

Microdon ellipticus 1331

37. Lateral view of the specimen (2x). Spergen Hill, Ind.

Edmondia (?) subplana 1332

38. Lateral view of the type specimen. Natural size.

Goniophora (?)plicata 1332

39. Lateral view (3x) of one of the origina. specimens.

late XXIII.

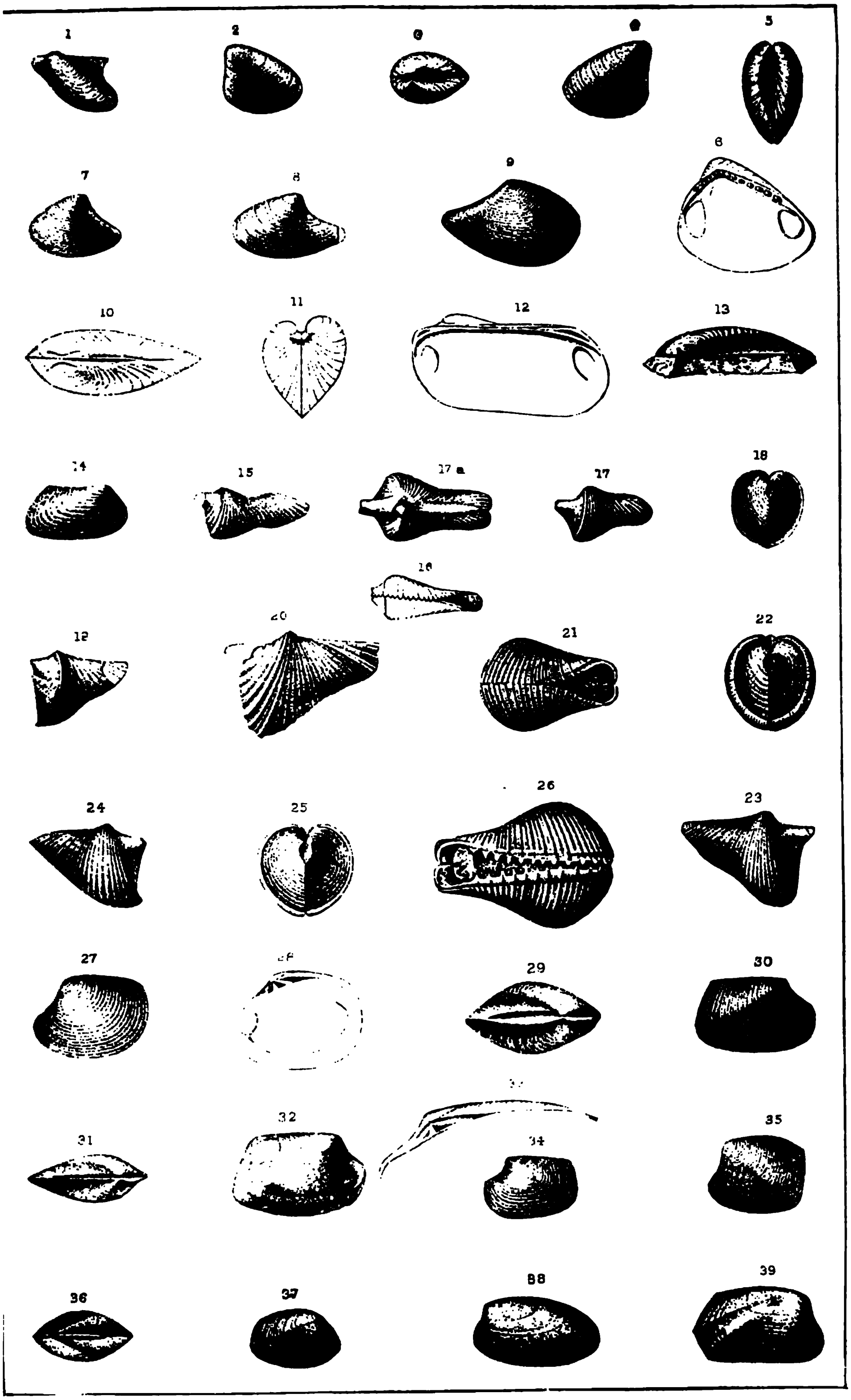
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PLATE XXIV.

Page

Aviculopecten sp. . . . .

1. View of right valve.

1a. Portion of surface enlarged. Spergen Hill. Indiana University collection.

Macrodon sp. 1333

2. Left valve. Spergen Hill. Indiana University collection.

Macrocheilus sp. 1341

3, 3a. Spergen Hill.

Griffithides bufo 1370

4. After Meek and Worthen.

Bellerophon Gibsoni 1361

5, 5b. After White.

Polytremaria (?) solitaria n. sp. 1364

6. Lateral view (enlarged), showing perforations.

6a. Top view, showing spire. Spergen Hill. Indiana University collection.

Subulites Harrodsburgensis n. sp. 1363

7. Posterior view.

7a. Anterior view.

7b. Detail of aperture. Harrodsburg, Ind. Indiana University collection.

Gryphochiton (?) parvus 1365

8. Anterior segment.

8a. Body segment.

8b. Posterior segment.

8c. Profile of last. Harrodsburg, Ind. Indiana University collection.

Soleniscus glaber n. sp. 1363

9, 9a. Anterior and posterior views. Spergen Hill. Indiana University collection.

Macrocheilus Stinesvillensis n. sp. 1341

10, 10a. Anterior and posterior views. Stinesville, Ind. Indiana University collection.

Platyceras circularis 1363

11, 11a. Apertural and profile views. After Rowley. Lanesville, Ind. G. K. Greene collection.

Anomphalus rotuliformis n. sp. 1364

12, 12a. Apertural and top views. Spergen Hill. Indiana University collection.

Orthoceras sp. 1368

13, 13a. Edwardsville, Ind. G. K. Greene collection.

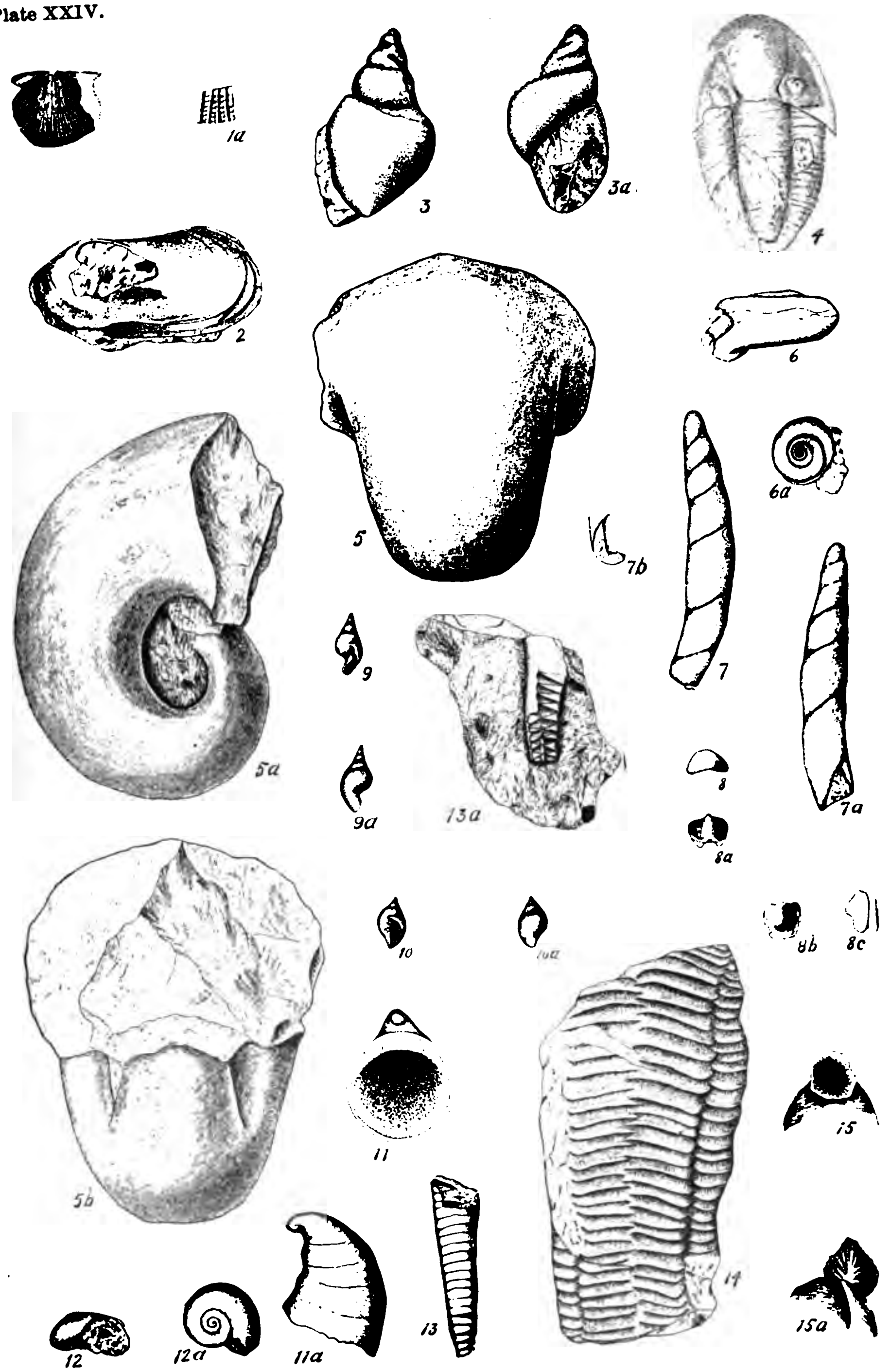
Conularia Greenei 1367

14. Spergen Hill? G. K. Greene collection.

Acmaea (?) sp. 1366

15, 15a. Lanesville, Ind. G. K. Greene collection.

Plate XXIV.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15a

PLATE XXV.

Page

Nautilus Clarkanus 1369
1. Lateral view of the specimen described.

Orthoceras epigrus 1368
2. x2.

Conularia subulata 1366
3. Lateral view x2.

Bucanopsis textilis 1362
4, 5. Dorsal and lateral view (x2). Bloomington, Ind.

Bellerophon sublaevis 1360
6, 7.

Lepetopsis Levettei 1337
8. Lateral view of a young specimen doubtfully of this species (x4).
9. Top view of a large individual.
10. Same with shell removed to show muscular scar.
11. View of a second individual.
12. Profile of 10 and 11.

Orthonychia acutirostre 1385
13, 14. Lateral and dorsal views of same specimen.
15. Lateral view of a second specimen. Both Bloomington, Ind.

Straparollus spergenensis 1337
16-19. Typical *S. spergenensis*. From Spergen Hill.
20, 21. So-called var. *planorbiformis*. From Bloomington, Ind.
22, 23. So-called *S. planispira*. From Bloomington, Ind.
24, 25. So-called *S. quadrivolvis*. From Bloomington.

Strophostylus carleyana 1340
26, 27. Posterior views. Natural size. View of aperture (x2). Bloomington, Ind.

Macrocheilus littonanus 1341
28. Anterior view (x4).

Cyclonema leavenworthana 1344
29. From Spergen Hill (x2).
30. From Bloomington. Natural size.
31. Aperture of specimen from Spergen Hill (x2).

Cyclonema subangulatum 1345
32. Posterior view of type (x2).

Holopea proutana 1342
33, 34. Anterior and posterior views (x2). Spergen Hill.

Loxonema yandellana 1346
36. Fragment showing striae (x3).
35. Another specimen (x3).

Bulimorpha bulimiformis 1343
37. Specimen from Bloomington, Ind. (x2), showing columella.
38. Lateral view of smaller specimen (x3), Spergen Hill, showing sinus in upper part of lip.
39. Anterior view of another Spergen Hill example (x3).

Bulimorpha elongata 1344
40. Type (x2).

Bulimorpha canaliculata 1343
41. Type (x3) showing the channeled sutures.

Plate XXV.

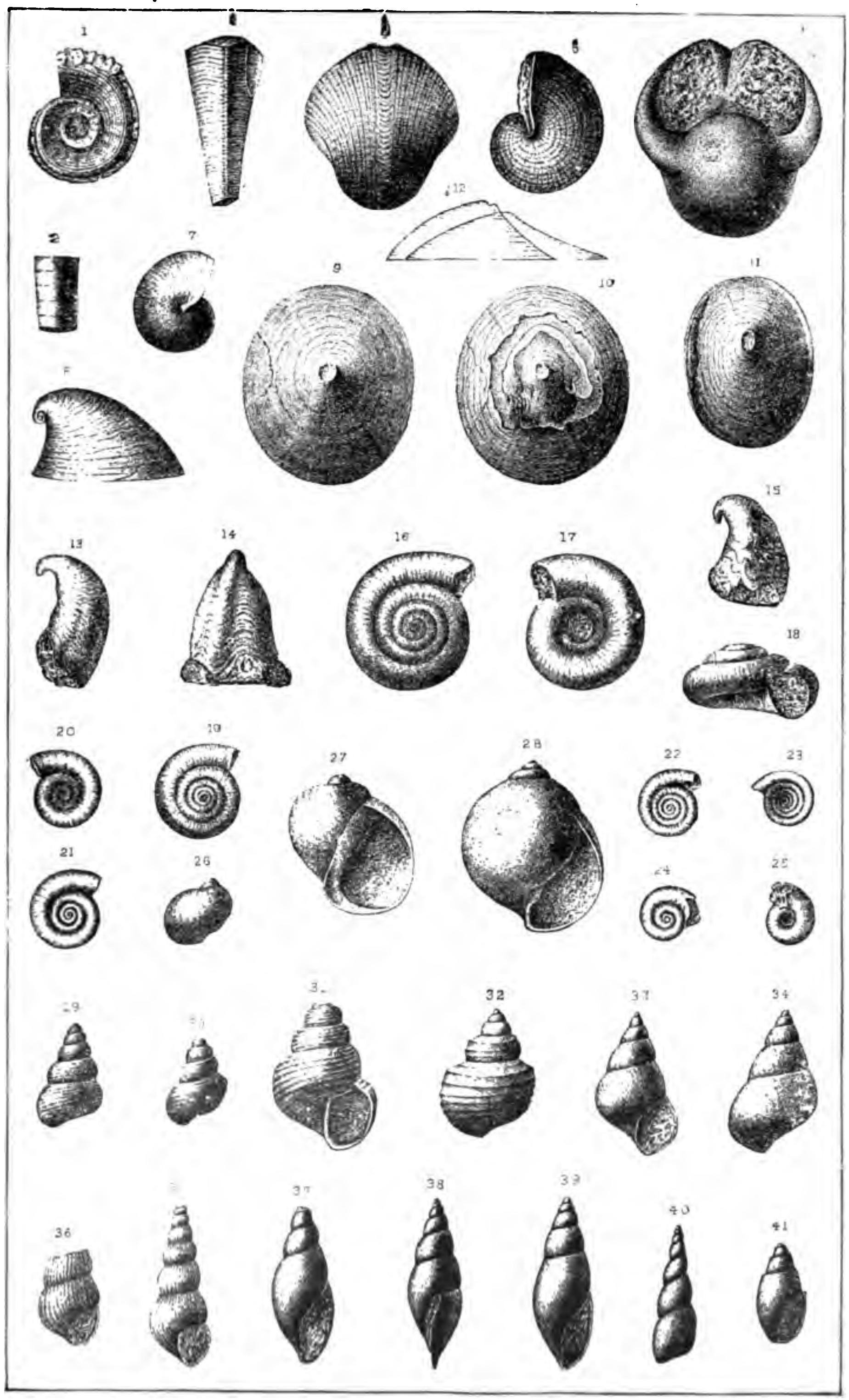

PLATE XXVI.

Page

Pleurotomaria (?) Swallovana 1349
1, 2. Vertical and lateral views of a specimen from Spergen Hill, Ind. (x4).
3. Top view (x4) of so-called *P. humilis*.

Pleurotomaria (?) wortheni 1351
4. Apertural view of type. (See other figures, Geol. Iowa, 1858).

Pleurotomaria (?) nodulostriata 1350
5. Apertural view (x4) of a specimen of medium height.

Pleurotomaria (?) piasaensis 1353
6, 7. Lateral and top views of a specimen with sharp periphery (x3).

Pleurotomaria (?) Meekana 1352
8, 9. Lateral and top views of type slightly restored (x3).

Pleurotomaria (?) subglobosa 1348
10. Lateral view, showing aperture (x2). Spergen Hill.

Solenospira vermicula 1357
11. Specimen from Spergen Hill (x5).

Solenospira turritella 1358
12. Specimen from Spergen Hill (x2).

Solenospira attenuata 1359
13. Type (x6).

Murchisonia (?) vincta 1359
14. View of the most perfect of the type specimens (x2).

Murchisonia (?) terebriformis 1357
15. View of the type (x2).
16. View of last volution, further enlarged and restored in lower part.

Pleurotomaria (?) conula 1354
17. View showing aperture with slit (x4).

Murchisonia (?) insculpta 1356
18. Specimen from Spergen Hill (x4).

Bembexia elegantula 1355
19. Type (x2).

Pleurtomaria (?) trilineata 1350
20. Specimen from Bloomington, Ind. (x3).

Eotrochus concavus 1347
21, 22. Lateral and basal views of a specimen from Spergen Hill (x2).
23. Section of a shell enlarged.

Leperditia carbonaria ....
24-27. Views of a specimen, greatly enlarged, showing the features of the species.

Cytherellina glandella ....
28, 29. Lateral and profile views of a specimen greatly enlarged.

Spirorbis annulatus 1271
30. View of the lower side of a specimen from Alton, Ill. (x2).

Spirorbis nodulosus 1272
31. Enlarged view of the type specimen (x4).

Pentremites conoideus 1263
32. Lateral view of a specimen. Natural size. From Spergen Hill.
33. Young example of *P. conoideus*. (This is the form described by Hall as *P. Koninckana*.) For other figures of this species see plates 45-47.

Endothyra Baleyi 1201
34, 35. Two views of the same specimen, greatly enlarged, showing prevailing form.
36. View, similarly enlarged, of a less symmetrical form.

Plate XXVI.

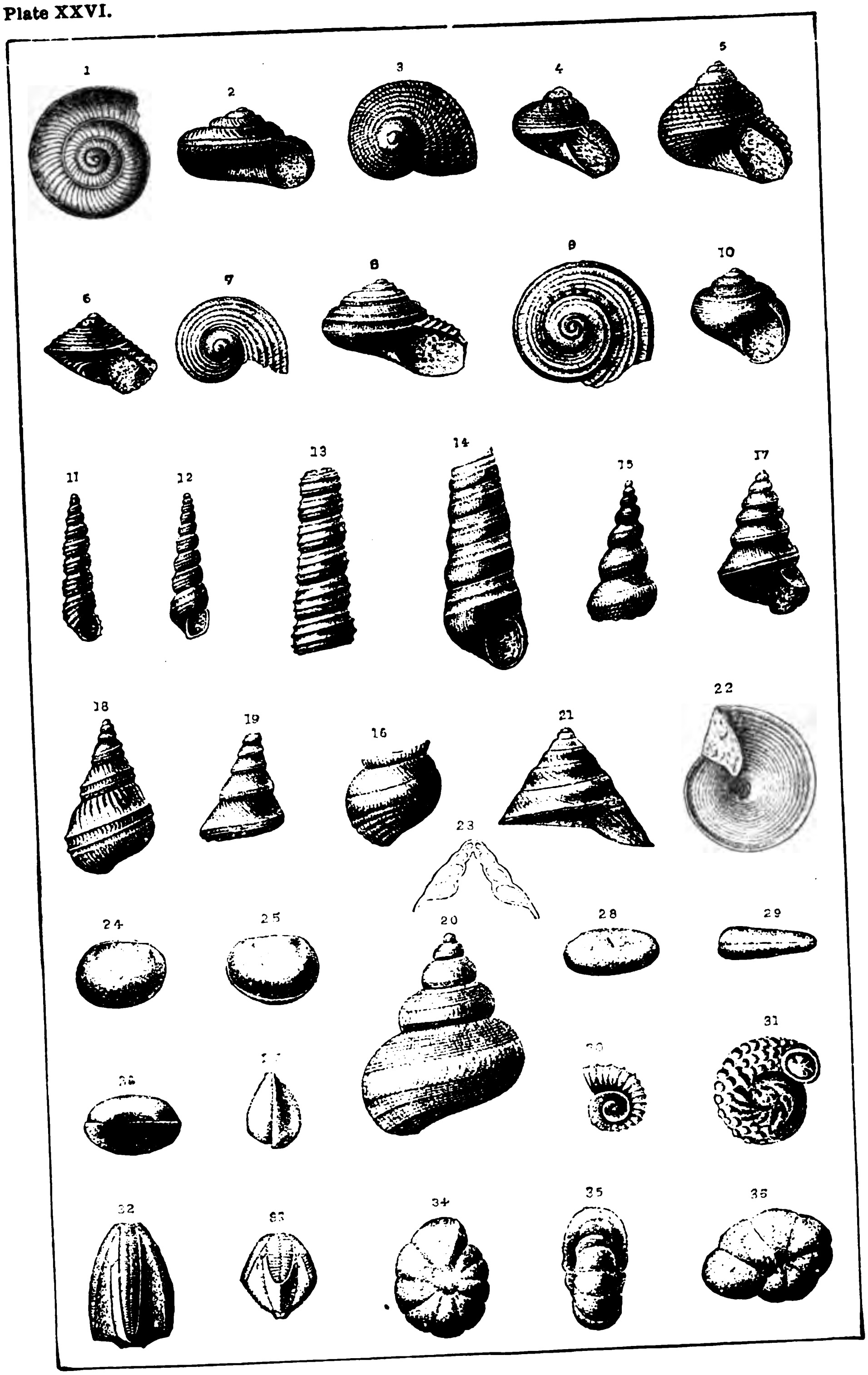

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PLATE XXVII.

Page

Fenestralia sancti-ludovici **1275**

1. An unusually robust example of this species (x8.5). Bedford, Ind.

1a. Obverse of a specimen, showing the normal form of the species. Collection of the U. S. National Museum.

Fenestralia sancti-ludovici* var. *compacta **1276**

2. Obverse of an example of this variety, showing the smaller branches and more numerous fenestrules (x8.5). Bedford, Ind.

Fenestella rudis **1277**

3. Portion of the obverse of the basal part of a frond, showing strong brace roots (x8.5).

3a. Reverse of same (x8.5).

3b. Obverse of another specimen (x8.5).

Plate XXVII.

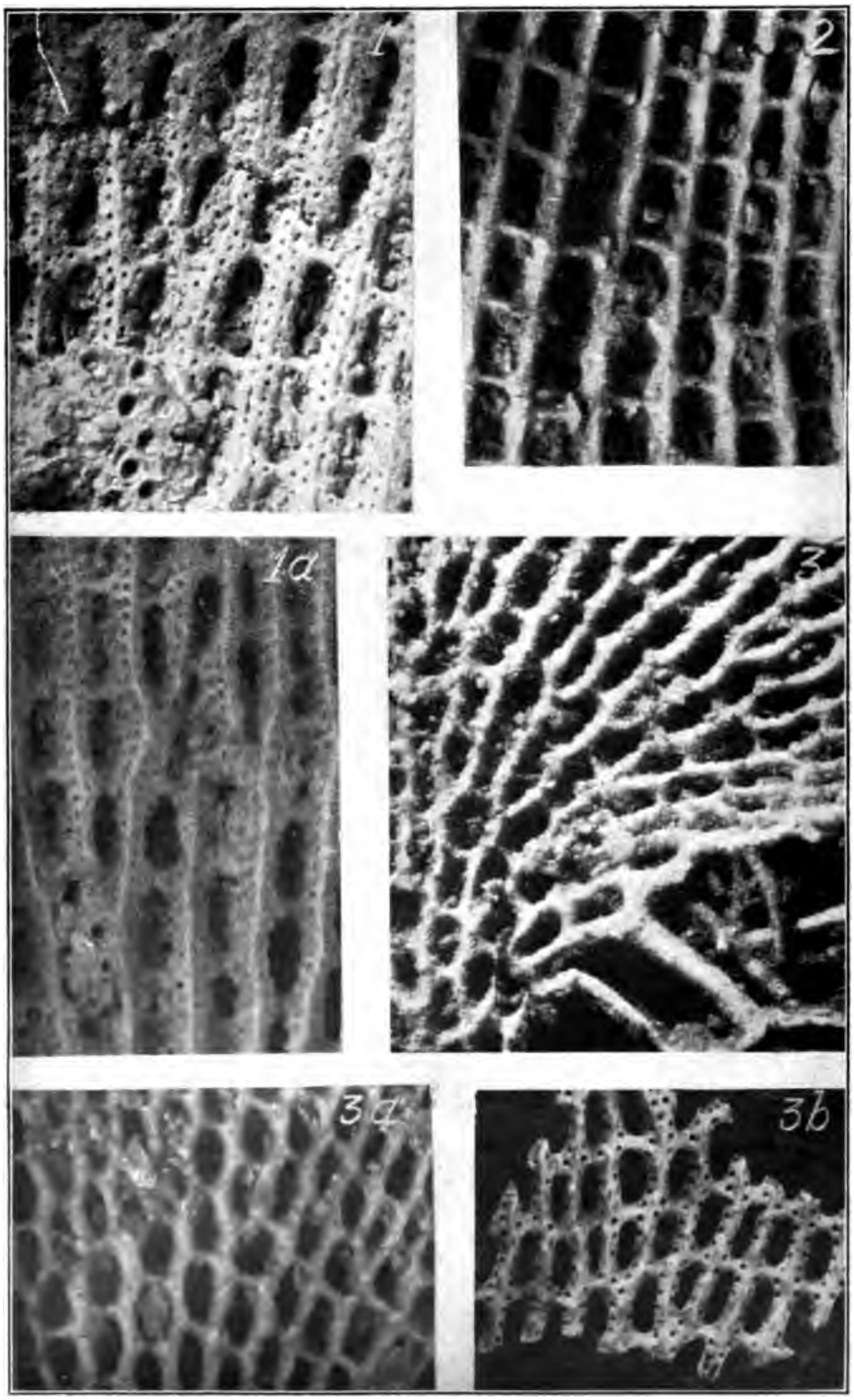

PLATE XXVIII.

Page

Fenestella compressa var. *elongata* n. var 1277

1. Portion of the obverse of a frond (x8.5), showing high, narrow carina and number and spacing of zooecia.

1a. Reverse of another specimen (x8.5), showing lax habit of growth and quadrate fenestrules.

1b. Obverse of another specimen (x8.5) with narrower fenestrules and somewhat more carinate dissepiments.

2. Obverse of a form in which the fenestrules are unusually short (x8.5).

2a. Reverse of a similar form (x8.5).

2b. Reverse of the normal form with elongate narrow fenestrules (x8.5).

2c. Obverse of a similar specimen (x8.5).

Fenestella exigua 1278

3. Reverse (x8.5), showing the large nodes at the angles of the fenestrules.

3a. Obverse (x8.5), showing carina with distant spines, etc.

Plate XXVIII.

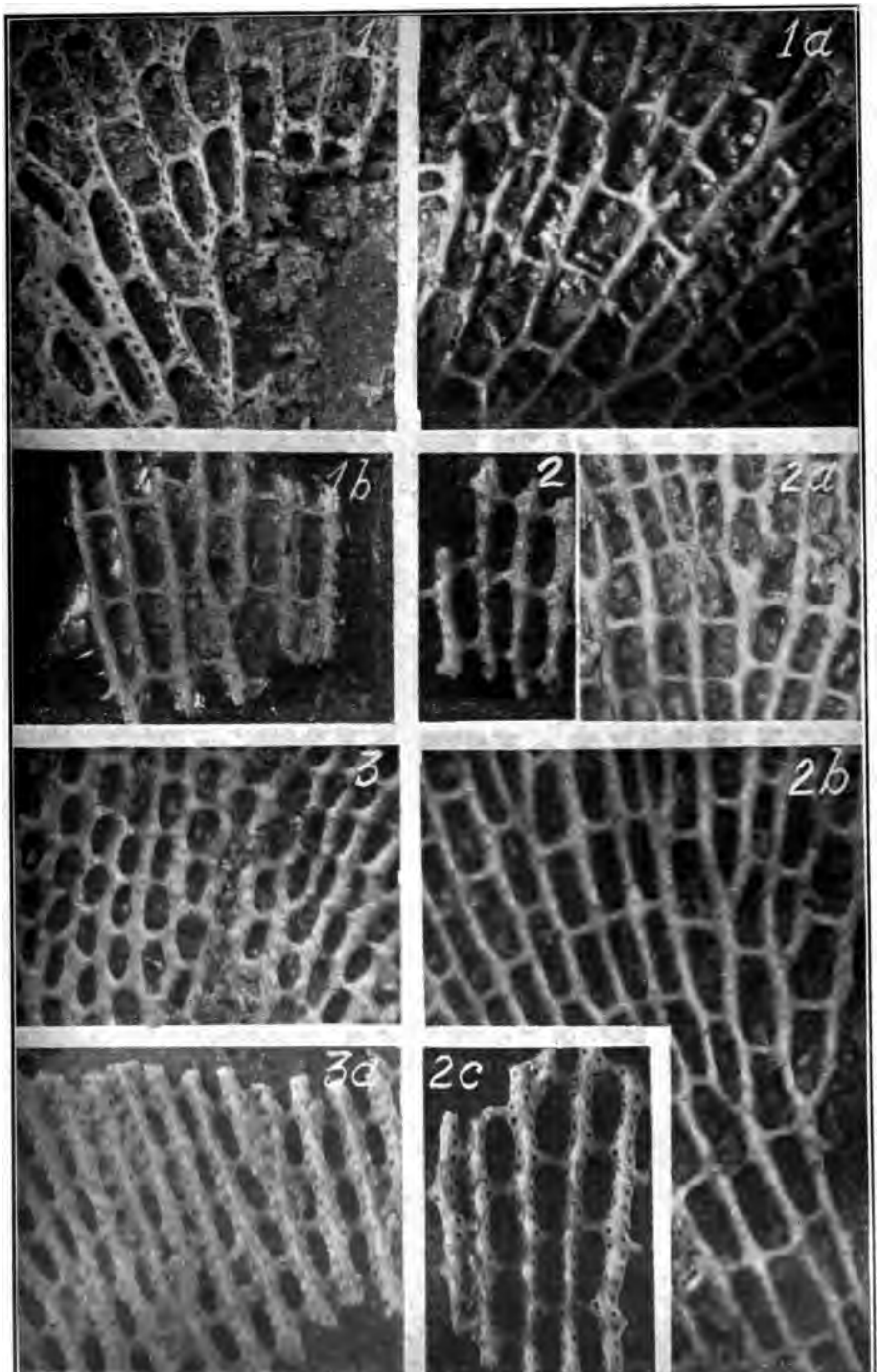

PLATE XXIX.

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Fenestella multispinosa 1278

1. Obverse of a frond, showing the opercular coverings of many of the zooecia (x8.5).

1a. Reverse of another specimen, showing rounded fenestrules in the mature portion of the frond, and numerous granules (x8.5).

1b. Reverse of another specimen, showing the granular-striate appearance of the younger portions of the zoarium and the rectangular fenestrules (x8.5).

1c. Obverse and reverse of a form in which the reverse of both the branches and dissepiments are covered with strong round nodes (x8.5).

1d. Obverse of a specimen, showing the spines on the dissepiments unusually large (x8.5).

1e. Obverse of a specimen, showing the prominent peristomes of the zooecia (x8.5).

Plate XXIX

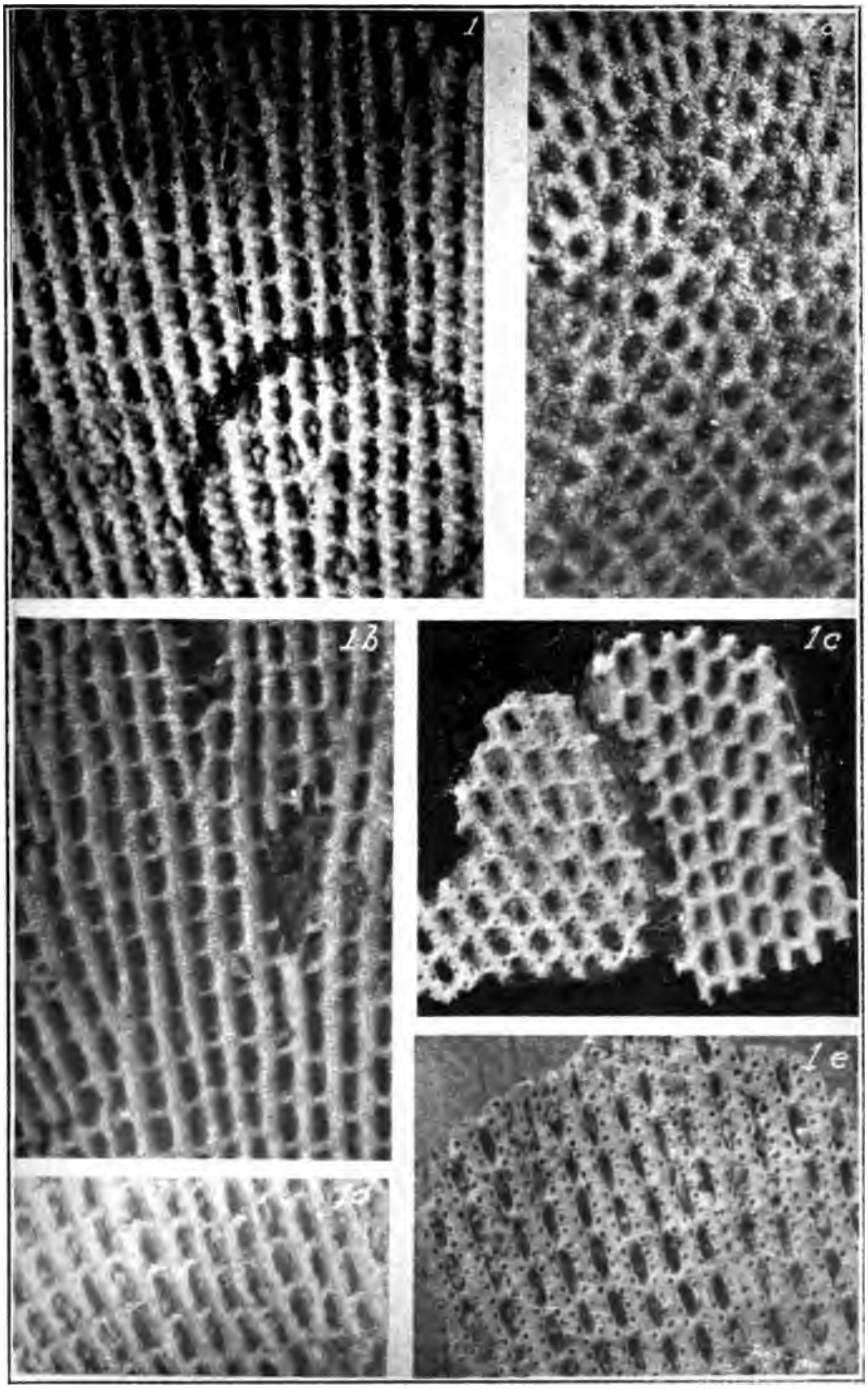

PLATE XXX.

Page

Fenestella tenax 1279

1. Specimen showing the carina and the prominent peristomes of the small zoœcia (x8.5). Bedford, Ind.

Fenestella serratula 1280

2. Reverse of a finely preserved specimen, showing granulose striae (x8.5). Bedford, Ind.

2a. Reverse of another specimen, showing variation in size of branches (x8.5). Bedford, Ind.

2b. Obverse of a specimen, showing the usual appearance of Bedford examples of this species.

2c. A very perfect example, showing the typical appearance of the species (x8.5). Bedford, Ind.

3. Obverse, showing the straight, close branches and serrate carina (x8.5).

3a. Reverse of another specimen. Bedford, Ind.

Fenestella tenuissima n. sp.. 1280

4. Obverse (x8.5).

Plate XXX.

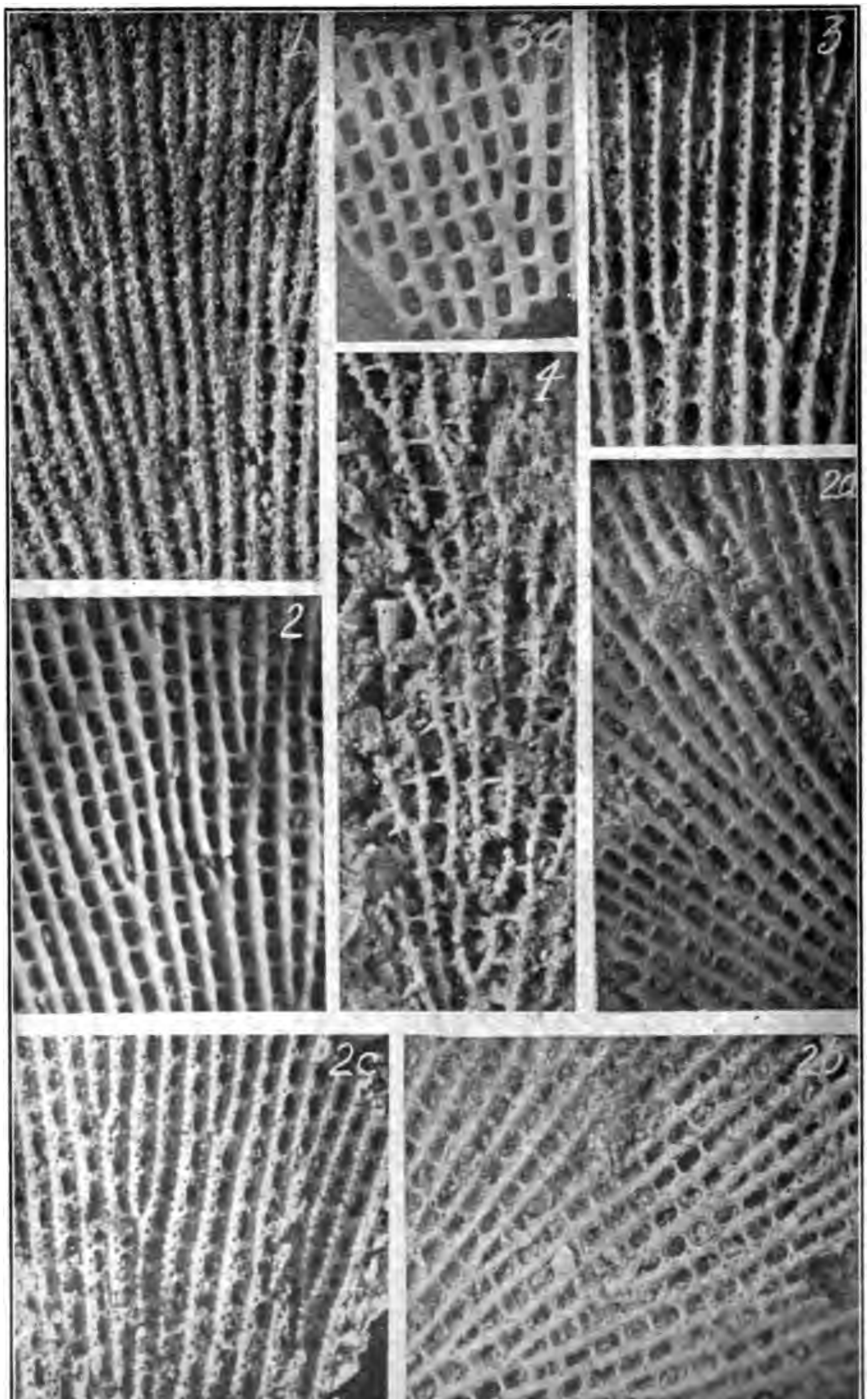

PLATE XXXI.

Page

Fenestella tenax 1279

1. Obverse of a fine specimen, showing the closely arranged branches and distant birfurcations (x7).

1a. Same specimen (x2). Bedford, Ind.

1b. Reverse of another specimen (x7). Bedford, Ind.

Fenestella tenax var. *multinodosa* n. var.............................. 1279

2. Obverse of a specimen, showing the numerous nodes arranged in a zigzag line (x7). Bedford, Ind.

2a. Reverse of another specimen (x7). Bedford, Ind.

Fenestella serratula var. *quadrata* n. var............................. 1280

3. Obverse, showing narrow branches and rectangular fenestrules (x8.5). Bedford, Ind.

3a. Reverse of another specimen (x7). Bedford, Ind.

Plate XXXI.

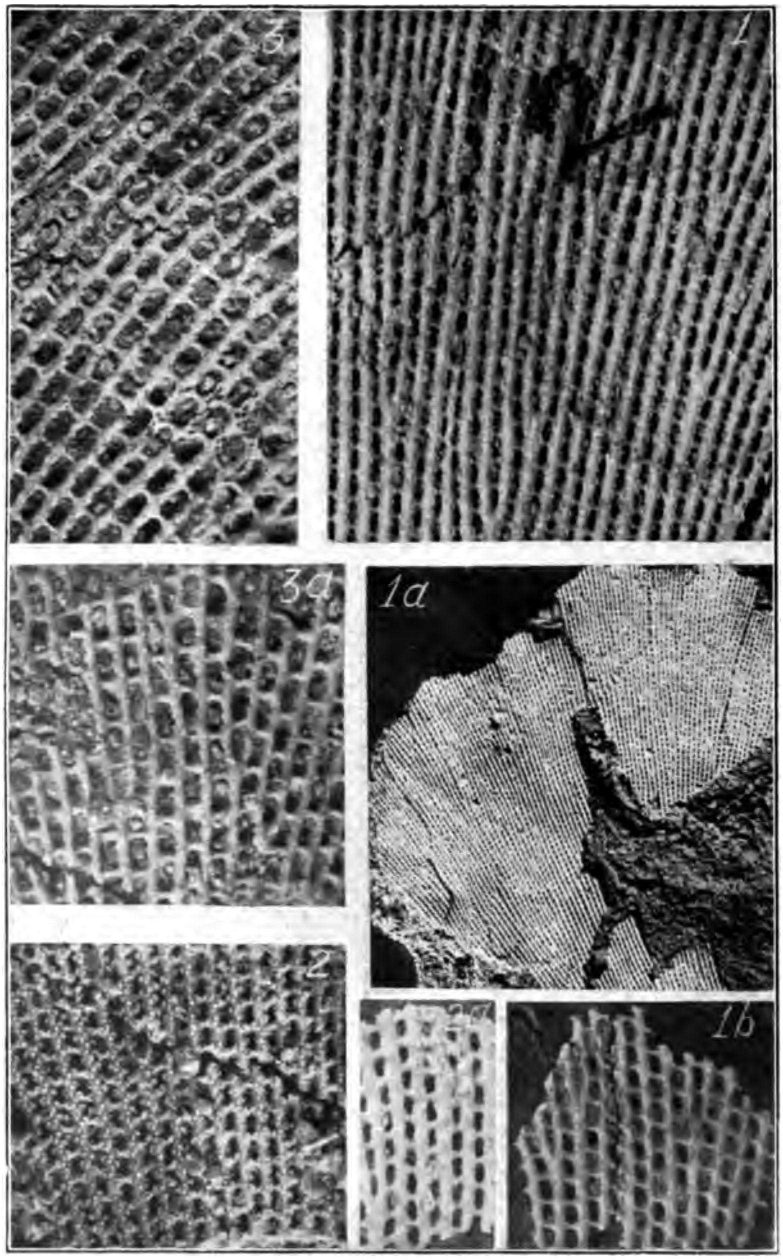

PLATE XXXII.

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Hemitrypa proutana var. *nododorsalis* n. var. 1282

1. Reverse, showing short, wide fenestrules and strong nodes at the angles (x7). Bedford, Ind.

1a. Obverse of another specimen (x7). Bedford, Ind.

1b. Another part of the same frond as the last, showing superstructure (x7).

1c. Obverse and reverse of a specimen in which the dorsal nodes are very prominent (x7). Bedford, Ind.

Hemitrypa proutana 1281

2. Reverse of a specimen, showing the normal appearance (x7). Spergen Hill, Ind. American Museum collection.

2a. Superstructure of another specimen (x7). Edwardsville, Ind. G. K. Greene collection.

2b. Superstructure of another specimen. U. S. National Museum collection.

Hemitrypa beedei n. sp. 1283

3. Reverse, showing strong striae (x7).

3a. Obverse of same specimen (x7).

3b. Superstructure of another specimen, showing pustules projecting into the interstices (x7).

3c. Reverse of same specimen, showing the slit-like fenestrules (x8.5). All from Bedford, Ind.

Plate XXXII.

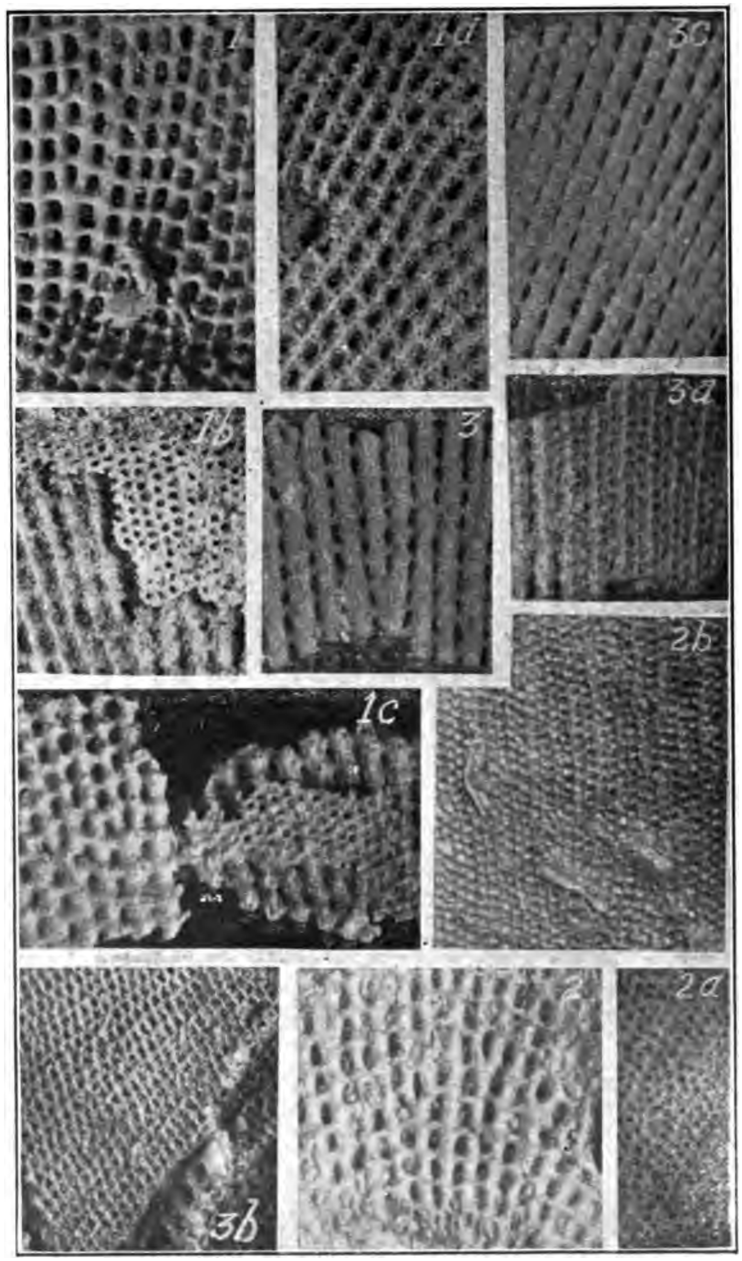

PLATE XXXIII.

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Polypora simulatrix 1284

1. Obverse of younger portion of a very large frond (x8.5).

1a. Obverse of older portion of same frond (x8.5). Bedford, Ind.

1b. Reverse of another specimen (x8.5). Bedford, Ind.

Polypora striata n. sp. 1285

2. Obverse of a specimen (x8.5). Bedford, Ind.

2a. Reverse of a portion of the younger part of a large frond, showing striæ (x8.5). Bedford, Ind.

Plate XXXIII.

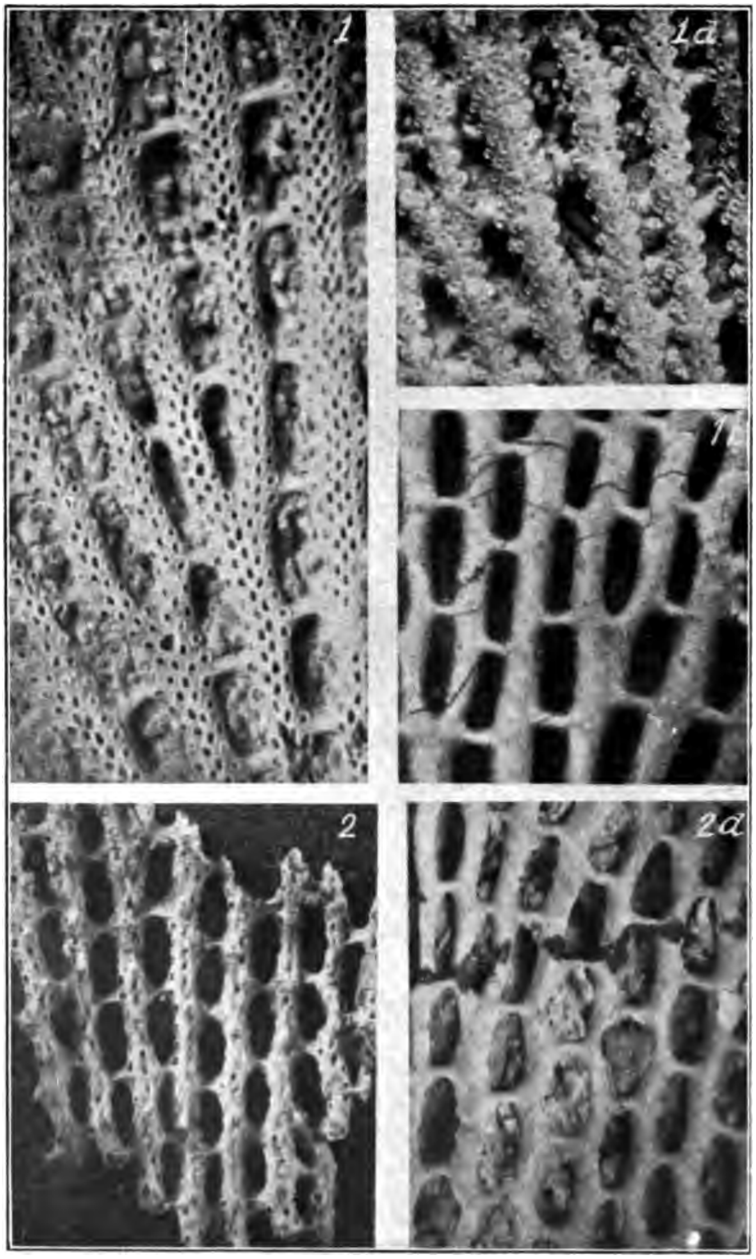

PLATE XXXIV.

Page

Polypora internodata n. sp. 1285

1. Reverse of a fine specimen, showing the spines or nodes on the dissepiments (x8.5).

1a. Obverse of another specimen (x8.5). Bedford, Ind.

Polypora biseriata 1286

2. Obverse of a somewhat weathered specimen (x8.5).

2a. Obverse of a more perfect example (x8.5).

2b. Reverse of same (x8.5). Bedford, Ind.

Pinnatopora sp. 1288

3. Obverse (x8.5).

3a. Reverse (x8.5). Bedford, Ind.

Dichotrypa flabellum 1288

4. Portion of a somewhat weathered frond (x8.5). Spergen Hill, Ind.

Plate XXXIV.

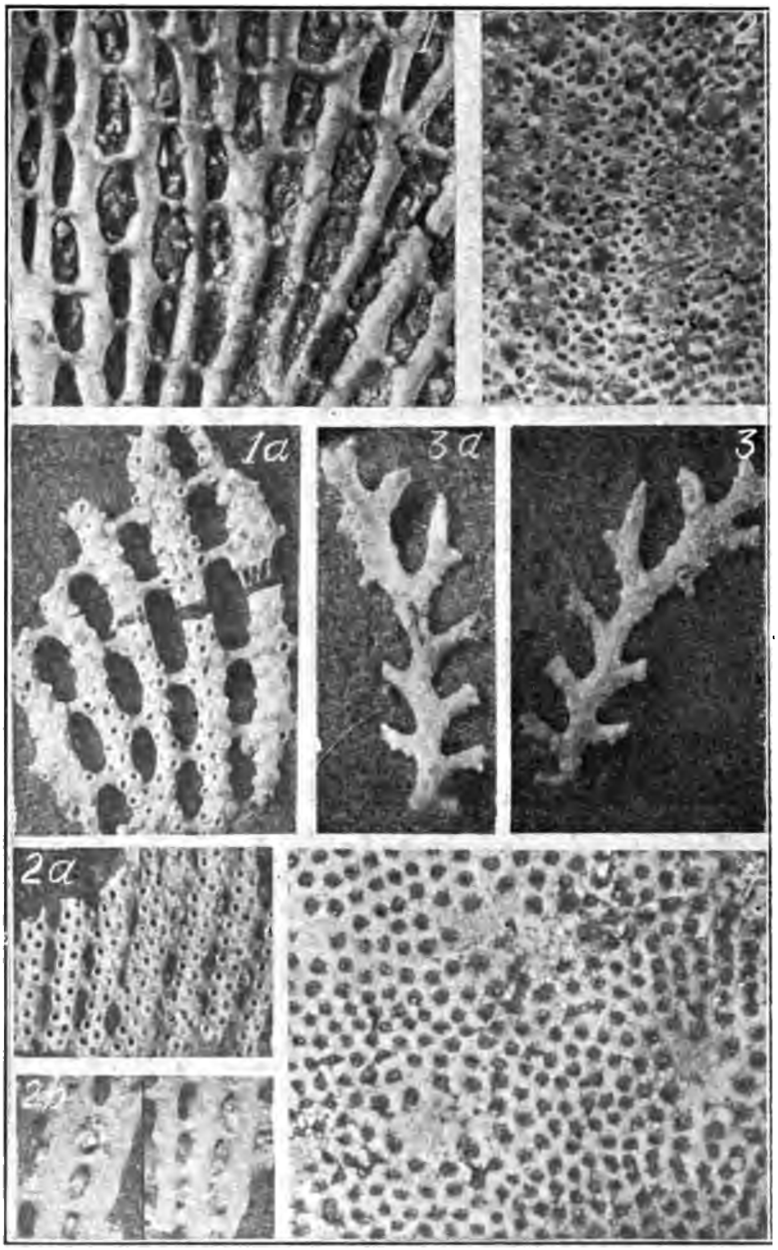

PLATE XXXV.

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Cystodictya lineata	**1289**
1. A bifurcating branch (x8.5). Spergen Hill, Ind.	
Cystodictya ocellata	**1290**
2. Bifurcating frond, showing the absence of longitudinal ridges and minutely granulose surface (x8.5). Bedford, Ind.	
Worthenopora spinosa	**1290**
3. Fragment showing breadth of frond and short subquadrate zooecia (x8.5). Bedford, Ind.	
Worthenopora spatulata	**1291**
4. Portion of a frond (x8.5). Bedford, Ind.	
Rhombopora bedfordensis n. sp.	**1292**
5. Specimen (x8.5), showing the general character of this species. Bedford, Ind.	
Dichotrypa sp.	**1288**
6. Portion of a frond (x8.5). Stinesville, Ind.	

Plate XXXV.

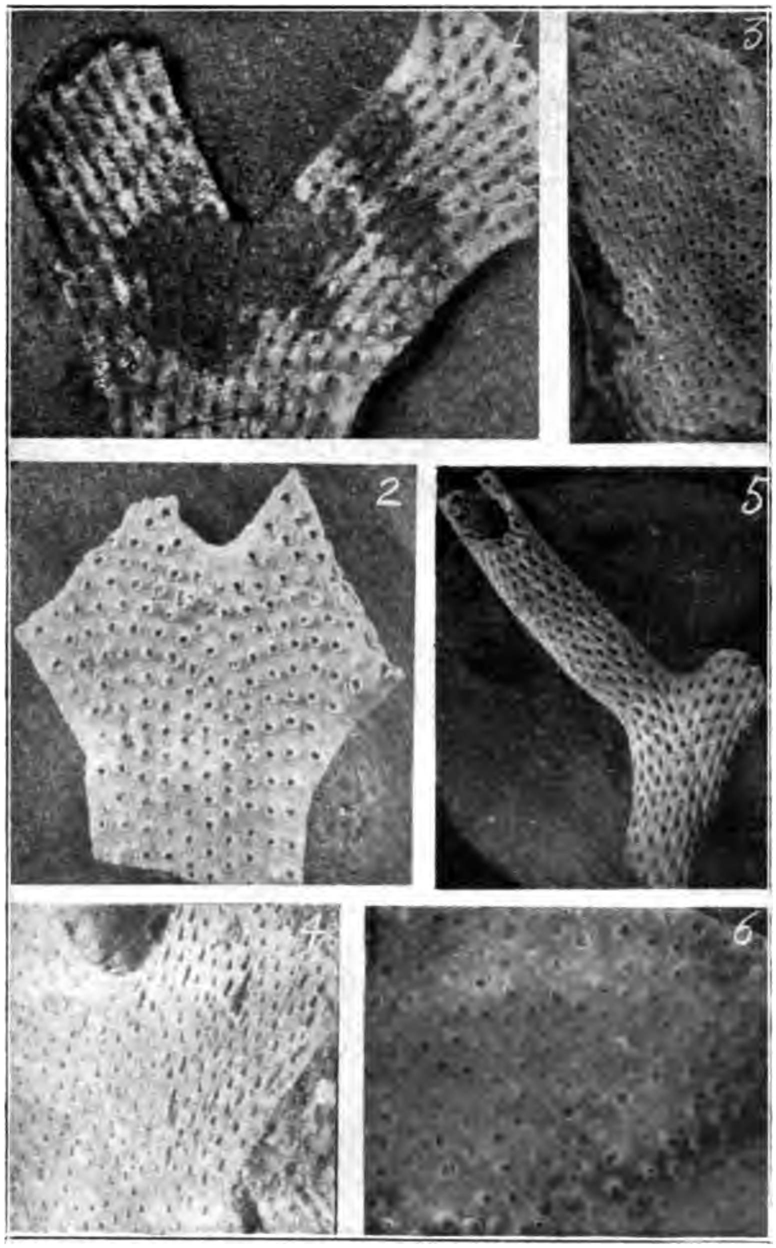

PLATE XXXVI.

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Glyptopora michelinia 1294

1. Portion of one of the cups of this species (x8.5). Bedford, Ind.

Stenopora sp.. 1295

2. Portion of an expansion, showing the mesospores and pustulose walls (x8.5).

Stenopora rudis 1295

3. Portion of a circular expansion, showing the large polygonal zoœcia (x8.5).

Fistulipora spergenensis var. *minor*.. 1293

4. Portion of a young colony, showing the strong zoœcial hoods.

Fistulipora spergenensis 1292

5. A beautifully preserved specimen from Bedford, Ind. (x8.5).
6. Specimen from the U. S. National Museum (x8.5).

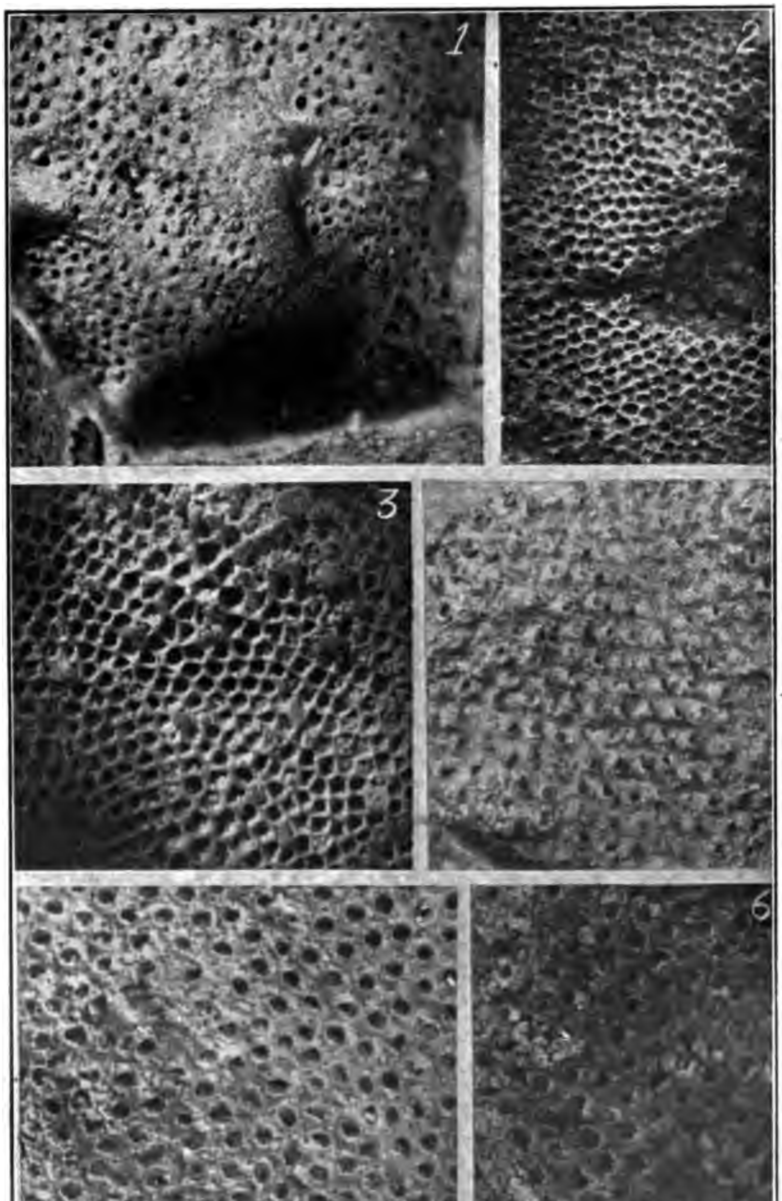
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PLATE XXXVII.

Portion of a large slab of limestone from Bedford, Ind., showing a portion of a large frond of *Polypora simulatrix* (*a*), and fronds of *Fenestella rudis* (*b*), *Polypora striata* (*c*) and *Fenestella serratula* (*d*). *a″* shows the portion of the frond of *P. simulatrix*, illustrated in 1, plate XXXIII, and *a′* shows the portion in 1a, plate XXXIII. Natural size.

XXXVII.

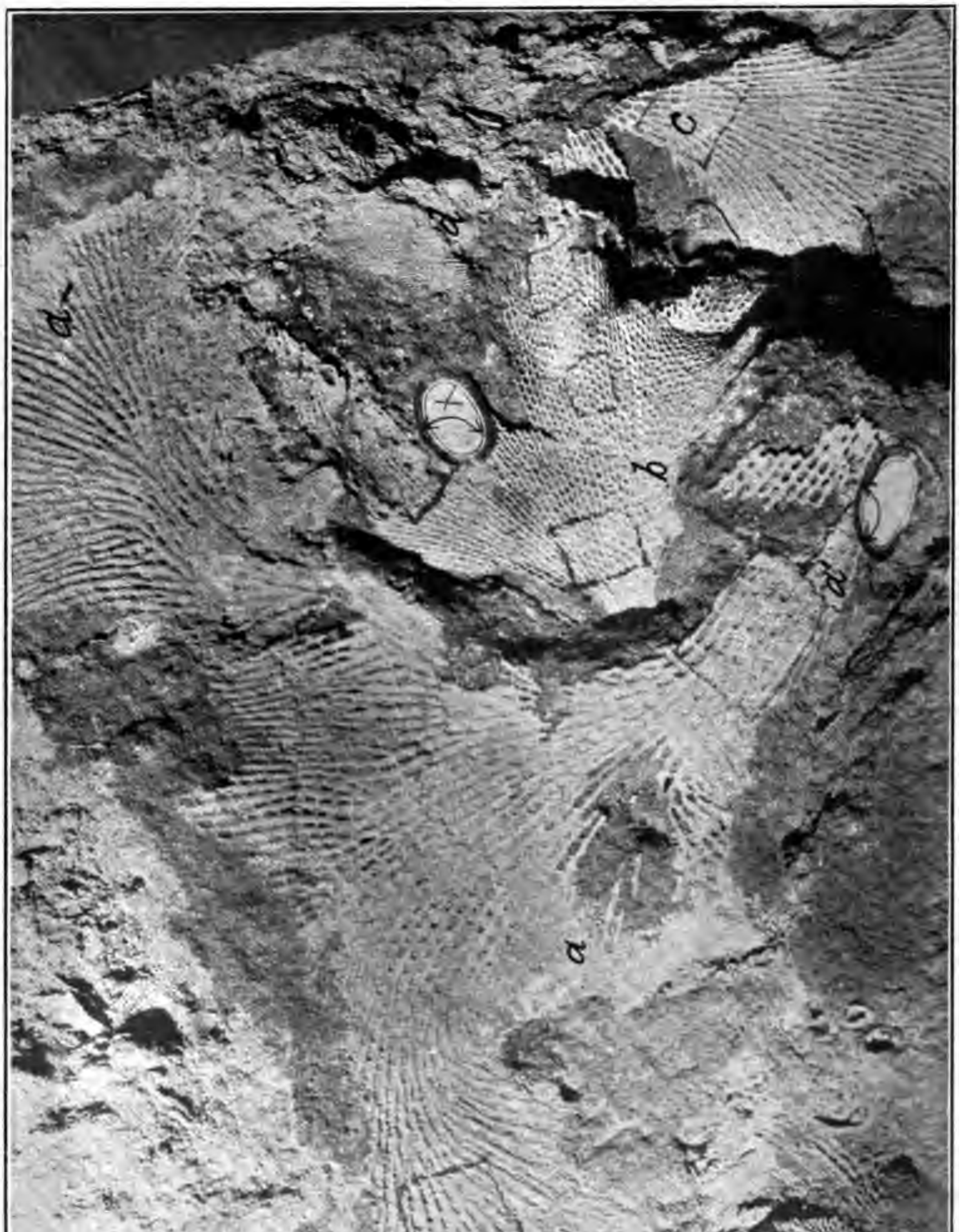

PLATE XXXVIII.

1. A frond of *Fenestella multispinosa*, showing the reverse. Natural size.

2. A handsome frond of *Fenestella compressa* var. *elongata*. Reverse side. Natural size.

3. Slab showing fronds of *Polypora simulatrix* (*a* and *c*) and *Fenestella compressa var. elongata* (*b*). Natural size.

4. Fronds of *Glyptopora Michelinia* (*a*), *Fenestella multispinosa* (*b*), and *Fenestella serratula* (*c*), and a *Stenopora* (*d*). Natural size.

5. Fronds of *Fenestralia Sancti-ludovici* (*a*), and *Fistulipora Spergenensis* (*b*). Slightly enlarged.

6. Large and very perfect specimen of *Fistulipora Spergenensis*. Natural size.

7. *Polypora simulatrix*. Natural size.

8. *Fenestella serratula*. Natural size.

9. Frond of *Fenestella exigua*. Natural size.

Plate XXXVIII.

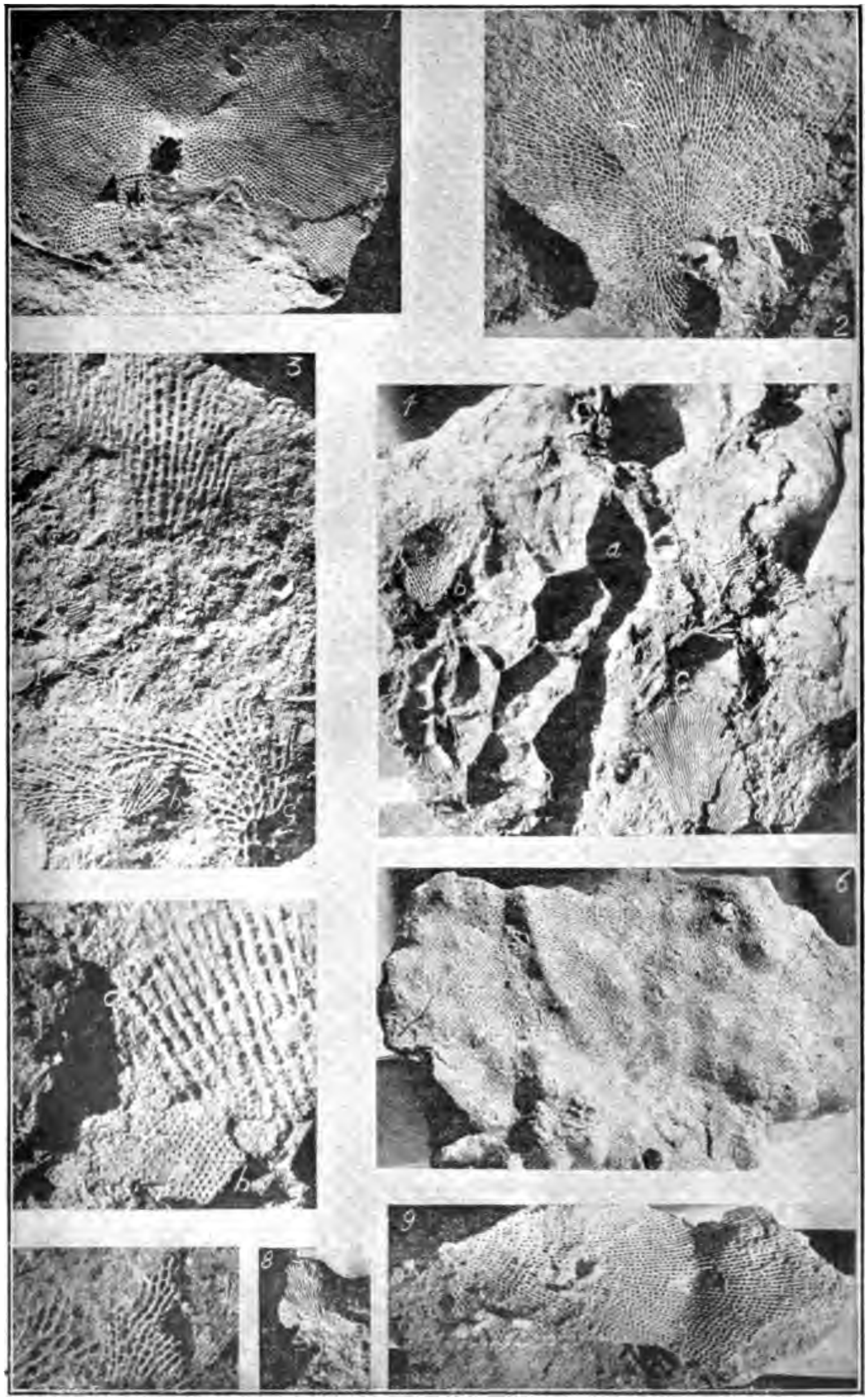

PLATE XXXIX.

Page

Polypora Maccoyana 1286

1. Obverse ($\times 8\frac{1}{2}$).

Polypora spininodata 1287

2. Obverse of a specimen from Bedford, Ind.
3. Obverse of a specimen in the collection of the U. S. National Museum.

Plate XXXIX.

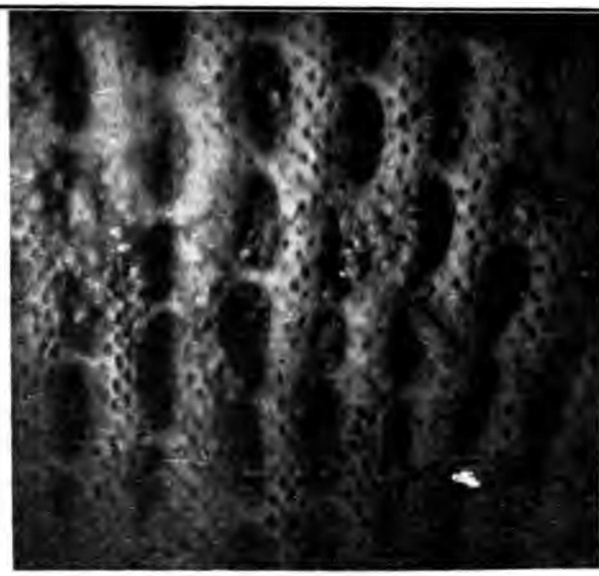

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PLATE XL.

Page

Polypora Maccoyana..1286

Large frond (x2).

Plate XL.

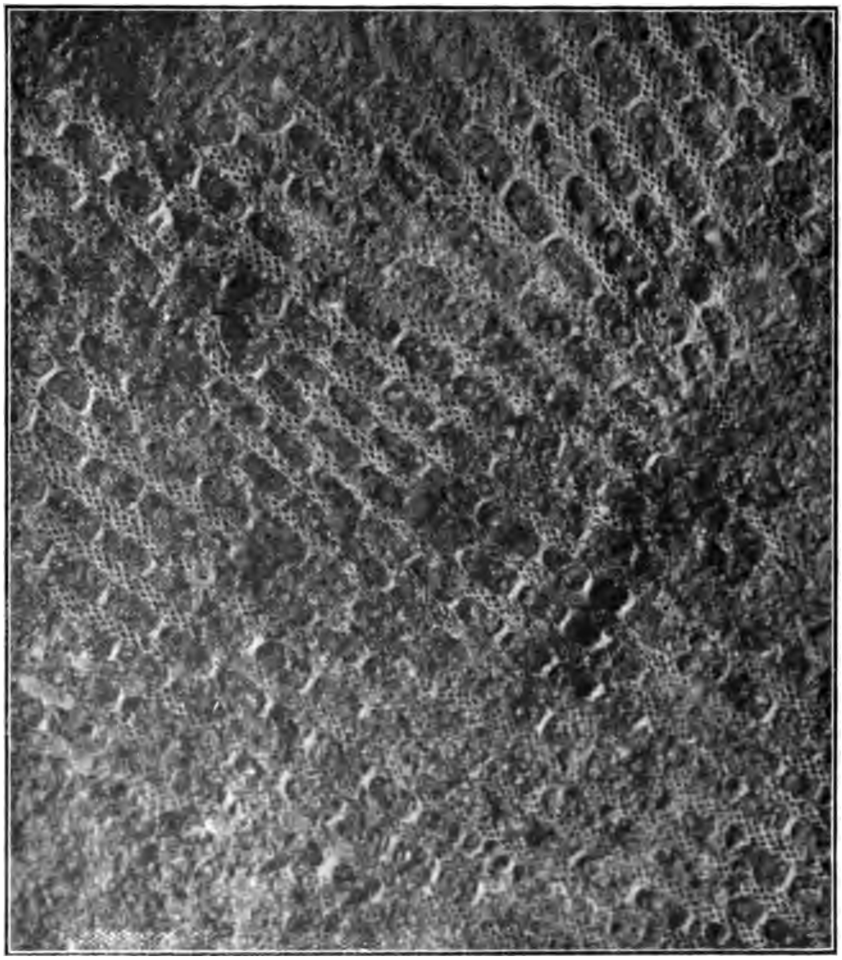

PLATE XLI.

Page

Cladodus spinosus Newberry and Worthen 1377
1-2. Views of top and anterior sides of tooth. (x½).

Cladodus ferox Newberry and Worthen 1376
3-4. View of top and anterior side of tooth. (x½).

Helodus coniculus Newberry and Worthen 1382
5-7. Section, anterior side, and posterior side of imperfect tooth.

Deltodopsis bialveatus St. John and Worthen 1391
8-9. Side and top views of imperfect tooth.

Helodus incisus Eastman 1382
10-12. Section, posterior, and anterior views of imperfect tooth.

Petalodus linguifer Newberry and Worthen 1379
13-15. Posterior view, section, and anterior view of tooth.

Helodus laevis Newberry 1381
16-17. Side views of two teeth.
18-20. Top views of three teeth.
21-22. Cross sections of two teeth.

Psephodus latus St. John and Worthen 1387
23. Top view of posterior maxillary or mandibular tooth.

Deltodus sp. indet 1391
24. Top view of imperfect tooth.

Ctenacanthus pellensis? St. John and Worthen 1393
25. Side view of fragment of large spine.

Sandalodus porcatus Branson 1386
26. Top view of type specimen. Drawn from photograph of type.

Deltodus trilobus St. John and Worthen 1389
27-28. Lateral and top views of imperfect tooth.

Chomatodus inconstans St. John and Worthen 1380
29-31. Top and side views and cross section of large tooth.

Psephodus regularis St. John and Worthen 1388
32. Top view of imperfect tooth.

Sandalodus occidentalis Leidy 1384
33. Top view of imperfect tooth.

Deltodus spatulatus Newberry and Worthen 1388
34. Top view of imperfect tooth.

Plate XLI.

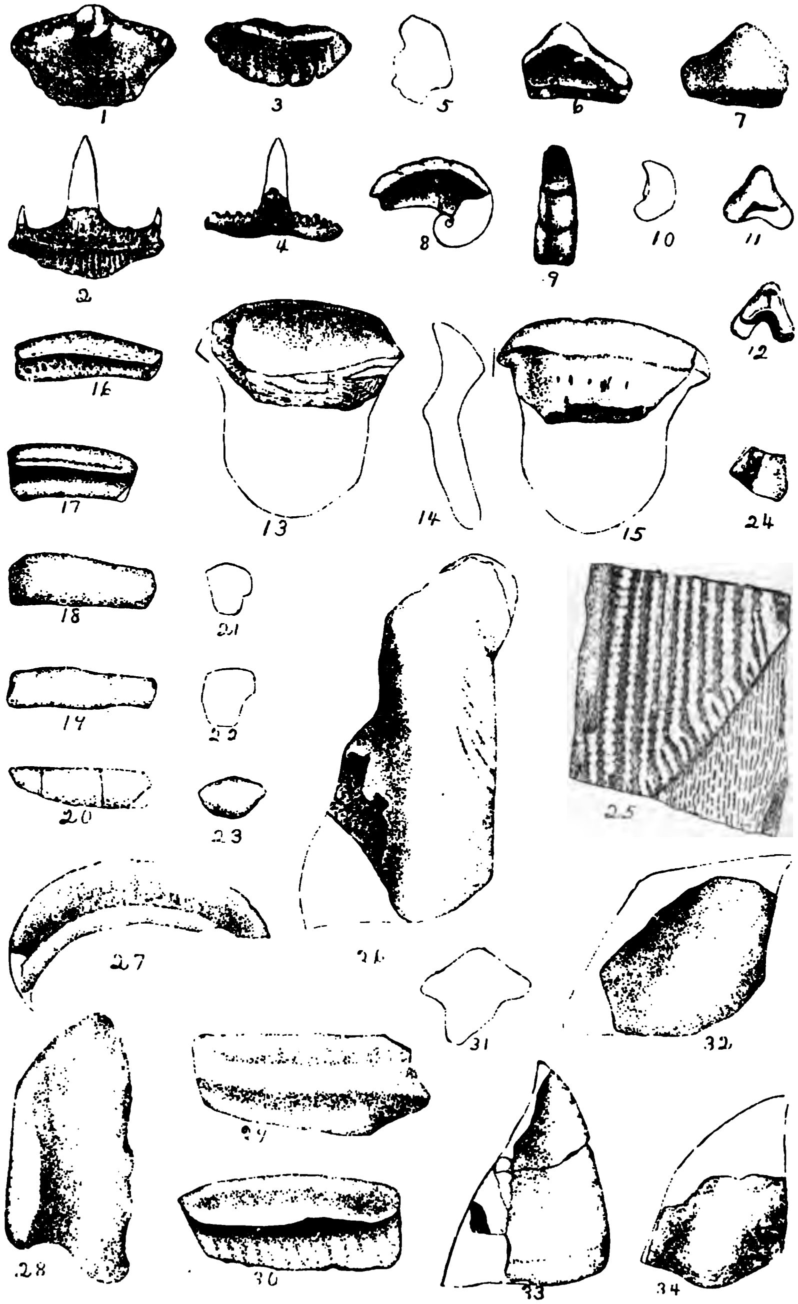

PLATE XLII.

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Cladodus striatus sp. nov... 1378
1-4. Anterior, posterior and side views and outline of base.

Cladodus indianensis sp. nov.. 1377
5-8. Posterior, side and anterior views and outline of base.

Cladodus lamnoides 1378
9, 10. Posterior and side views.

Cladodus sp. indet.. 1379
11. Anterior view of imperfect tooth.

Desmoidus salemensis sp. nov....................................... 1392
12-14. Posterior, side and anterior views of perfect specimen.

Chomatodus lanesvillensis sp. nov.................................. 1381
15-18. Anterior, posterior and top views, and cross-section of type specimen. One end broken away.

Ctenacanthus bellus sp. nov... 1393
19-21. Section, side and posterior views of fragment of spine.

Helodus robustus sp. nov.. 1382
22-24. Top, side and anterior views.

Orodus simplex sp. nov.. 1392
25, 26. Top and side views of tooth with one end broken away.

Helodus elegantulus sp. nov... 1383
27-29. Side and top views of tooth with one end broken away.

Gen. et sp. indet... 1394
30, 31. Top and side views of perfect tooth (x2).

Helodus minutus sp. nov... 1384
32-34. Bottom, side and top views (x2).

Orodus neglectus? 1391
35, 36. Side and top view of tooth retaining little more than the median.
37. Fragment of jaw of Elasmobranch.......................... 1394

Helodus ornatus sp. nov... 1383
38-40. Anterior, top and posterior views of tooth with a small part of one end broken away.

Deltodus cinctus 1390
41. Top view of tooth with inner end broken away.

Sandalodus convolutus sp. nov....................................... 1386
42-44. Views of anterior end, top, antero lateral and postero lateral sides. Inner end of tooth broken away.

Plate XLII.

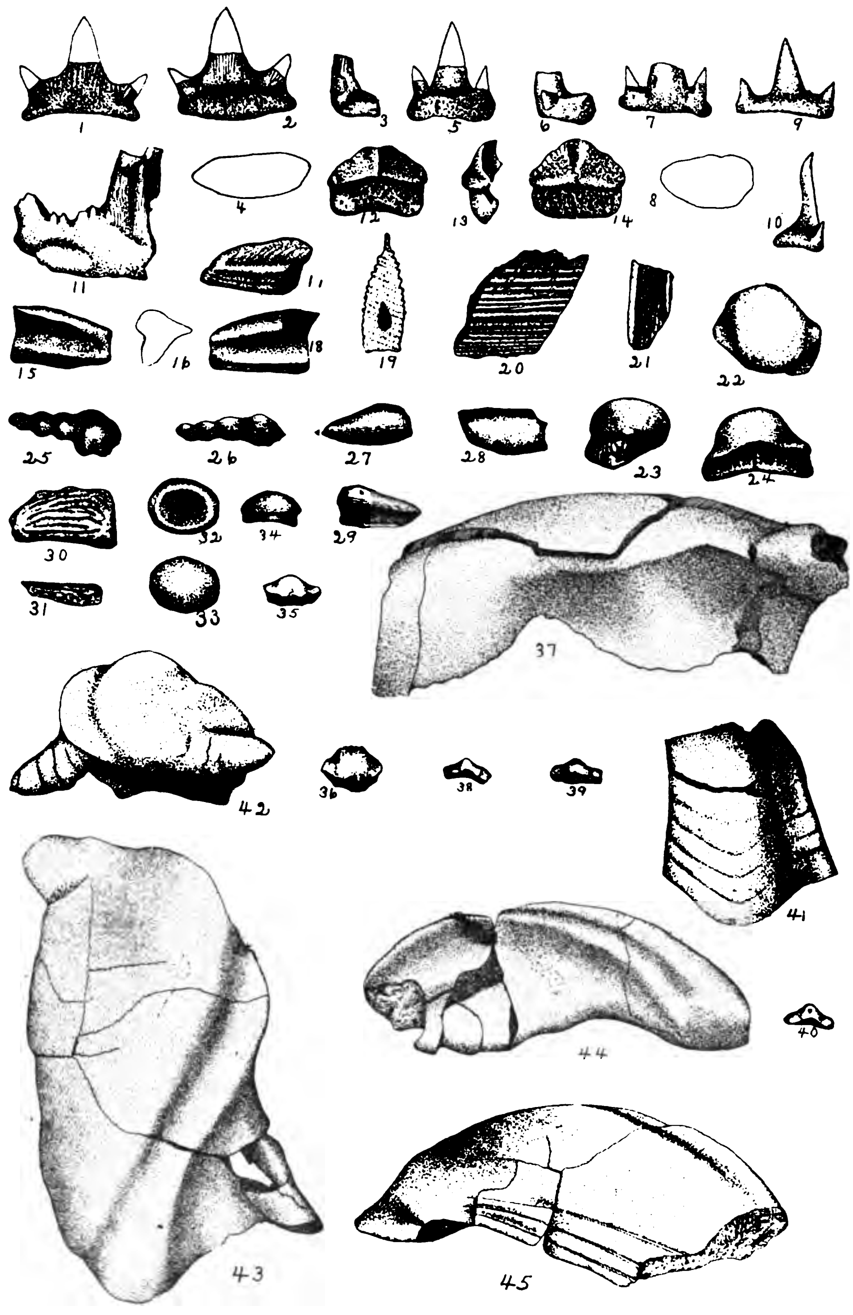
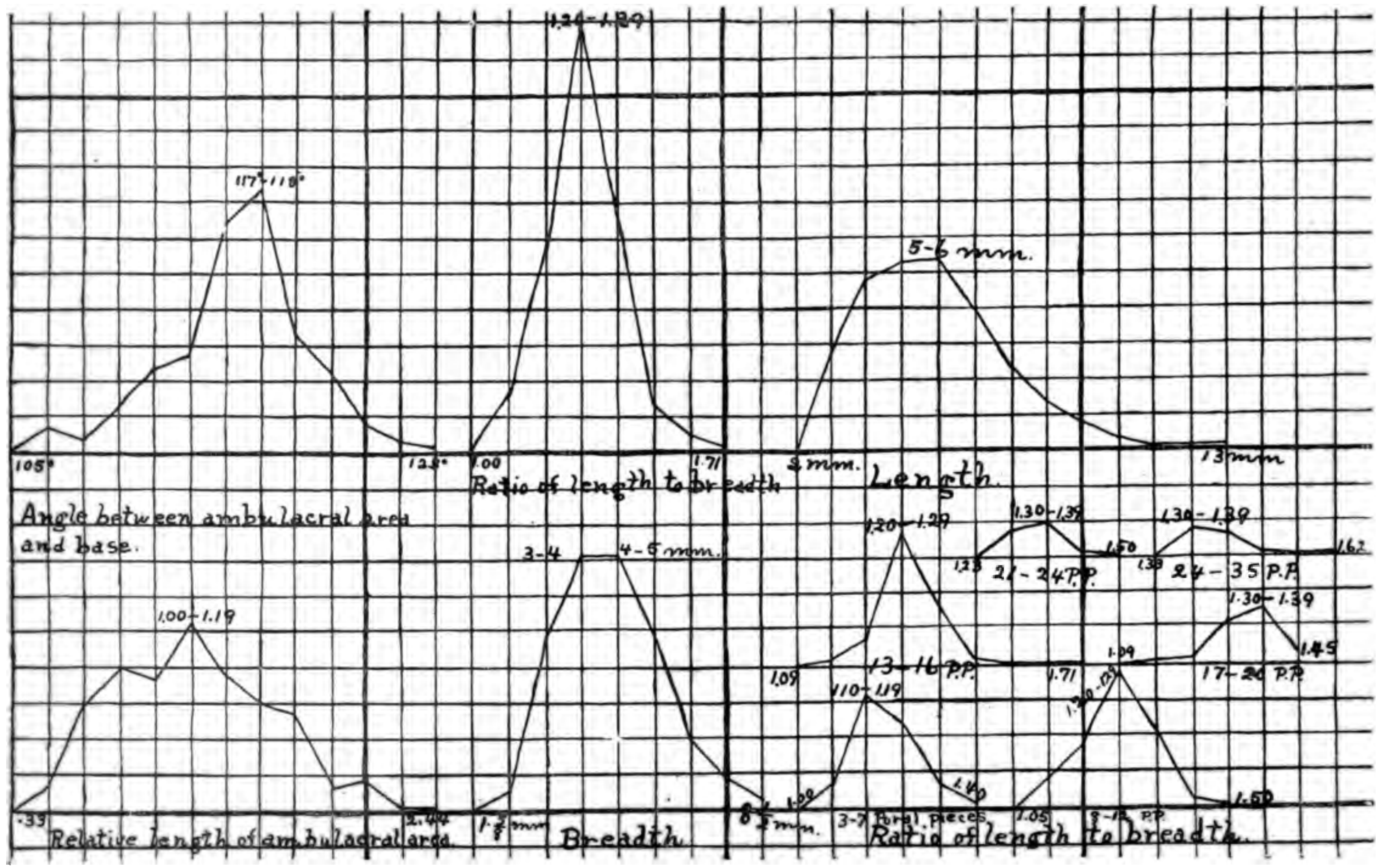


PLATE XLIII.

Pentremites conoideus.

Variation curves obtained from a study of the Harrodsburg specimens. Each of the five largest curves represents the variation of all the specimens from Harrodsburg. The six smaller curves in the right-hand corner are the curves obtained from the grouped data for the ratio of length to breadth.

Plate XLIII.

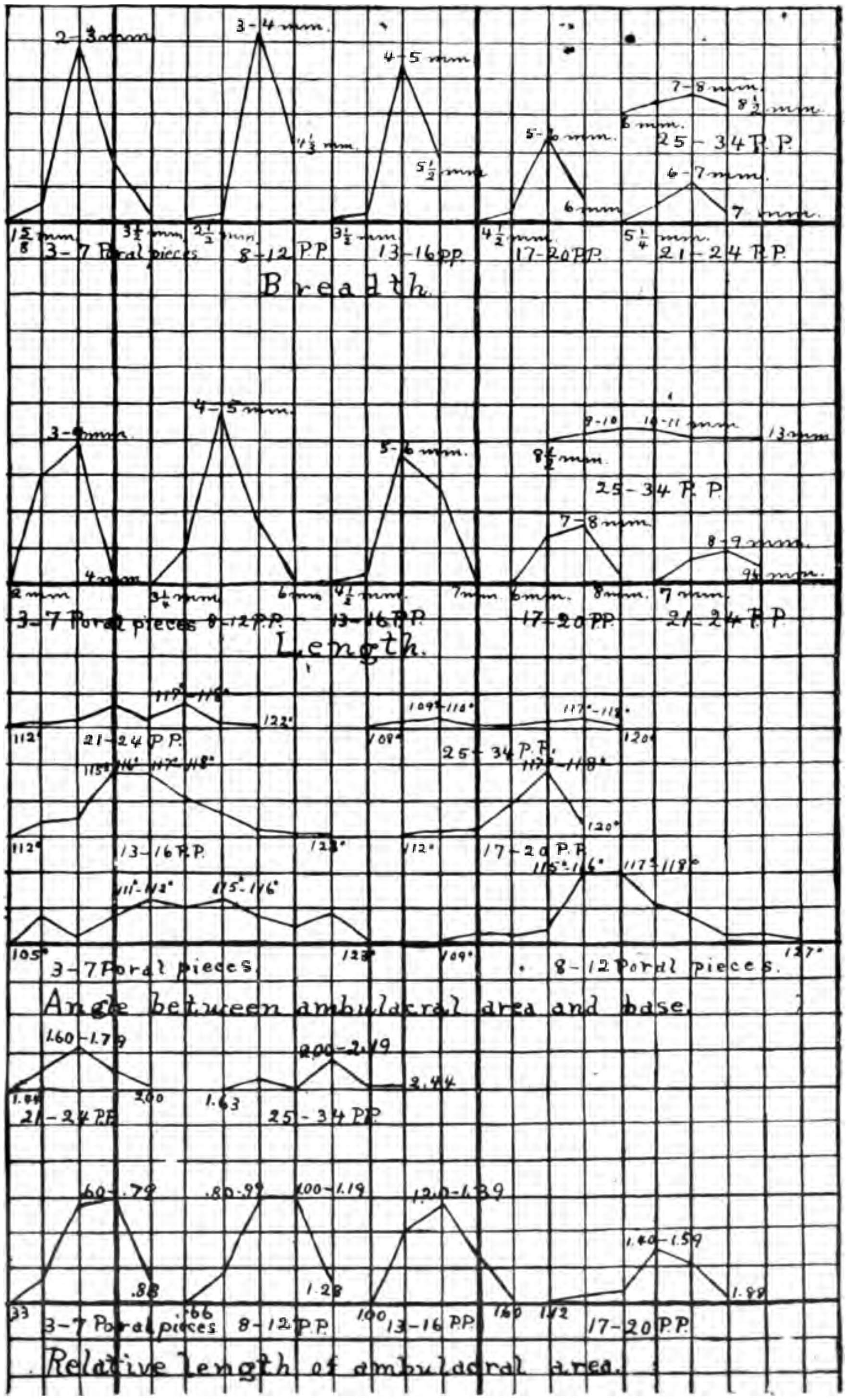


117°-118°
105°
125°
Angle between ambulacral area and base.
1.24-1.29
1.00
1.71
Ratio of length to breadth
5-6 mm.
8 mm.
13 mm
Length.
1.00-1.19
.33
2.44
Relative length of ambulacral area.
3-4
4-5 mm.
Breadth
1.20-1.29
1.09
13-16 P.P.
1.71
1.30-1.39
1.50
21-24 P.P.
1.30-1.39
1.62
24-35 P.P.
1.30-1.39
1.45
17-20 P.P.
1.10-1.19
1.40
3-7 Poral pieces
1.05
1.50
Ratio of length to breadth.

PLATE XLIV.

Variation curves obtained from the study of the grouped data of the Harrodsburg specimens of Pentremites conoideus. See page 1219.

Plate XLIV.



3-7 Poral pieces
8-12 P.P.
13-16 P.P.
17-20 P.P.
21-24 P.P.
25-34 P.P.
Breadth.
Length.
Angle between ambulacral area and base.
Relative length of ambulacral area.

PLATE XLV.

Figs. 1 and 2. Views of the distal portion of specimens of *P. conoideus*. In the upper central portion of Fig. 2 are shown some of the smallest specimens found.

Figs. 3, 4, and 5. Side view of same specimens as are shown in Fig. 2. Salem limestone, Harrodsburg, Ind. All figures in Plate III x 8½. Indiana University collection.

Plate XLV.

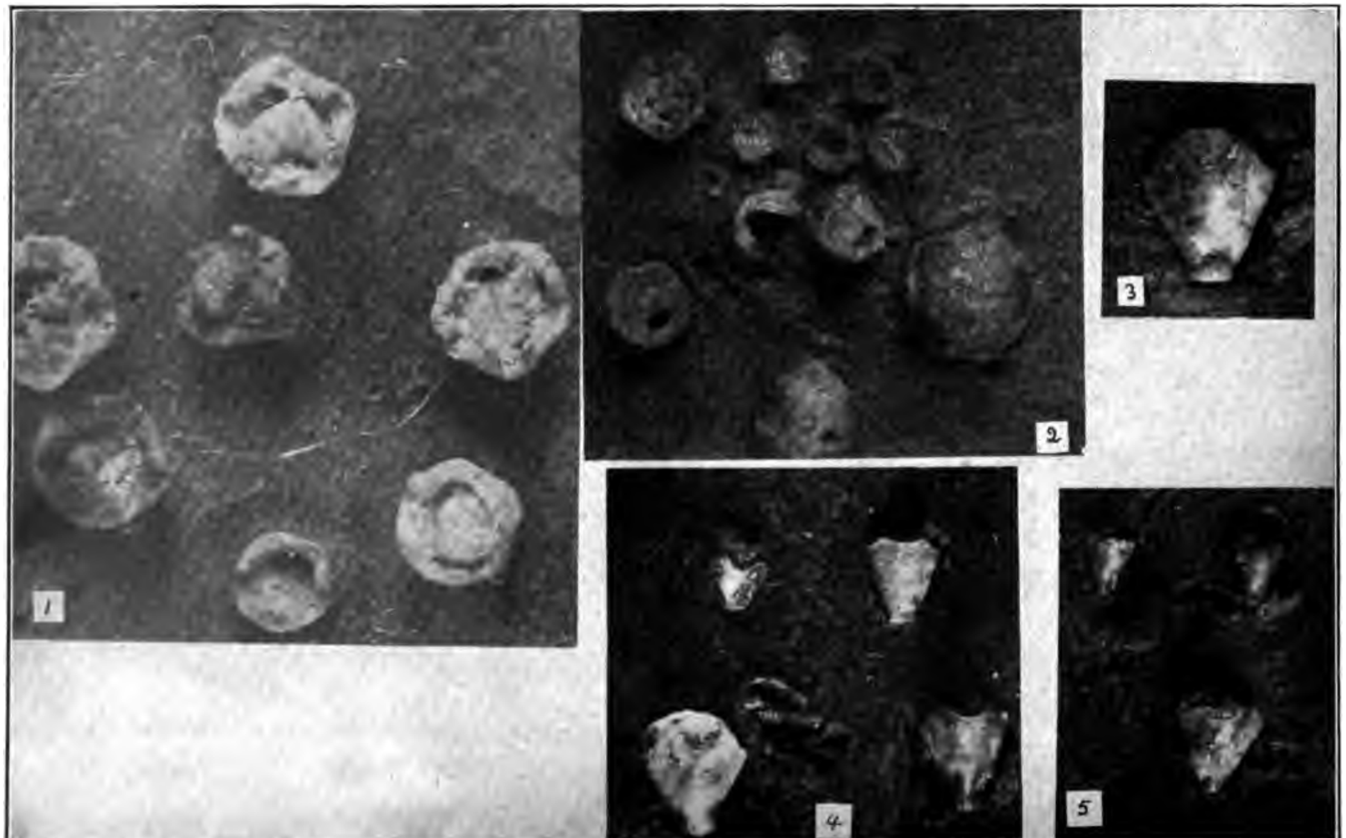


PLATE XLVI.

Fig. 1. Side view of a series of specimens of *P. conoideus*, ranging from the smallest to one of the largest specimens. The smallest specimens have no poral pieces, the largest one shown has 50.

Fig. 2. View of the distal portion of the same series. Specimens from Harrodsburg, Ind., Ellettsville, Ind., and Pentremite Hollow, Bloomington, Ind. All natural size. Indiana University collection.

Plate XLVI.

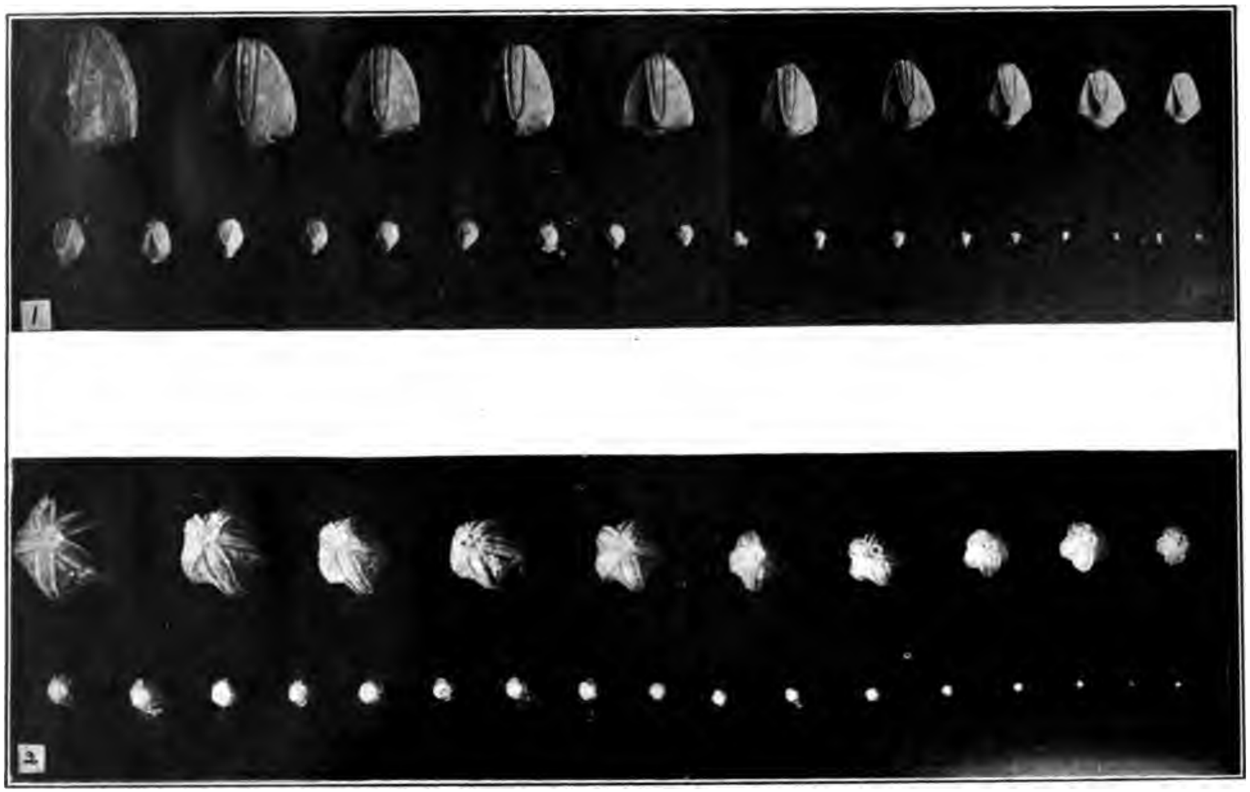


PLATE XLVII.

Fig. 1. A series of specimens of *Codaster* (natural size). from the Hamilton formation, Thedford. Ontario, showing the similarity in shape to the youngest specimens of *P. conoideus.*

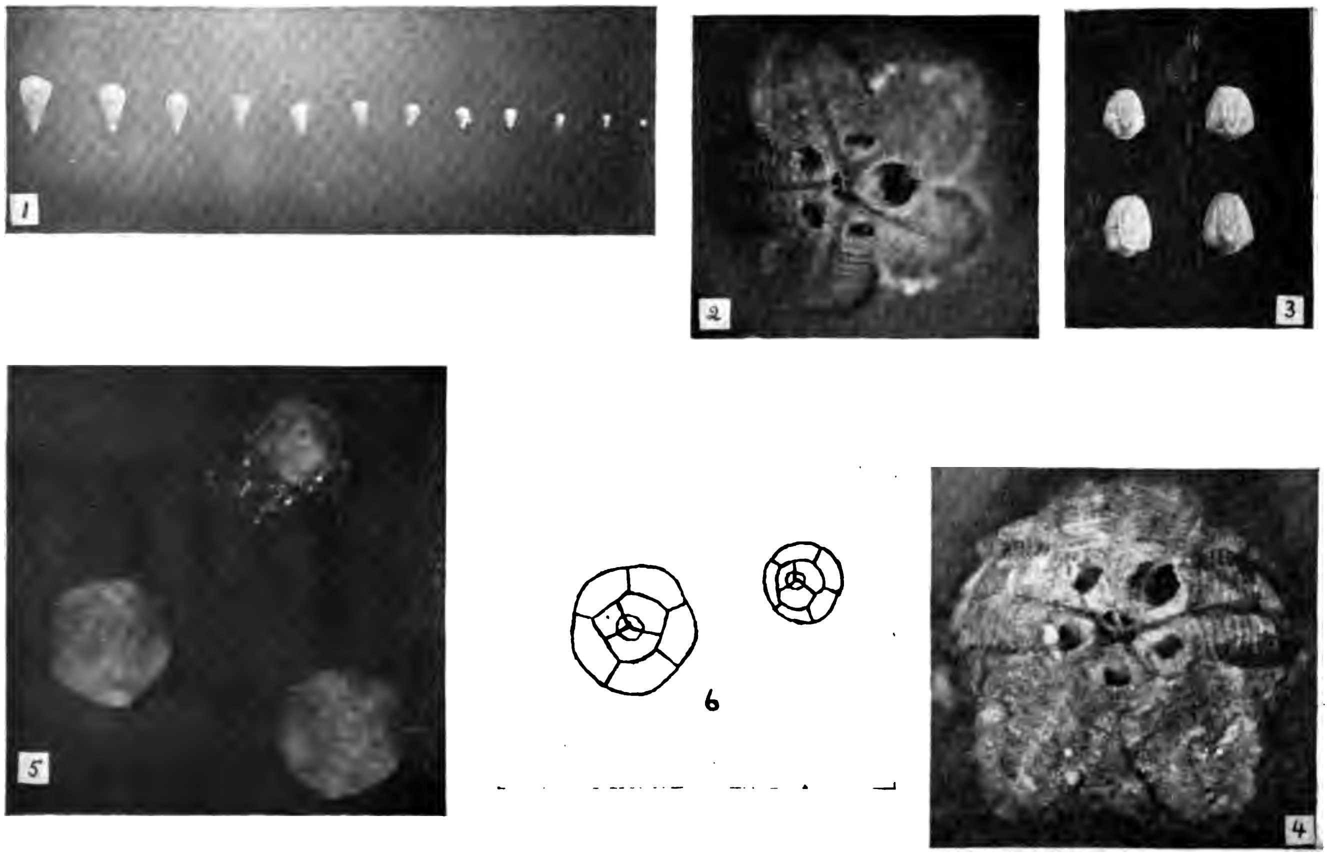
Figs. 2 and 4. Specimens of *P. conoideus* showing plates or septa in the mouth opening, Salem limestone, Lanesville, Ind., x 8½.

Fig. 3. Specimens from Harrodsburg and Pentremite Hollow, to show dwarfing of Harrodsburg specimens. The two upper specimens have the same number of poral pieces; to the left, Harrodsburg specimen, to the right Pentremite Hollow specimen. The two lower specimens are of the same length. Harrodsburg specimen to the left has 28 poral pieces, Pentremite Hollow specimen to the right has 24 poral pieces. Natural size.

Fig. 5. Specimen of *P. conoideus* showing the three basal plates x 8½. Salem limestone, Harrodsburg, Ind.

Fig. 6. Drawing from photograph of two of the specimens shown in Fig. 5. Specimens shown in Figs. 1, 3, 4, and 5, Indiana University collection. Specimens in Figs. 2 and 4, collection of Mr. G. K. Green.

Plate XLVII.



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